mercruiser

SERVICE MANUAL

Number 2

Stern Drive Units and Marine Engines

Sections 1 thru 10

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MODELS COVERED IN THIS MANUAL

MERCRUISER STERN DRIVE ENGINES (MCM)	
Model	**Serial Number**
MCM 120	3770650 - 4952700
MCM 140	3771645 - 4918569
MCM 165	3774865 - 4884834
MCM 470	4886619 and Below
MCM 888	3777490 and Above
MCM 898	4887829 and Below
MCM 225 S (Ford)	All
MCM 225TR (Ford)	3779775 and Above
MCM 228	4902304 and Below
MCM 228TR	All
MCM 233	All
MCM 250 (350 CID)	4768000 and Above
MCM 255 (Ford)	3838788 and Above
MCM 25 (GM)	4175500 and Above
MCM 280	All
MCM 330	4889679 and Below
400 Jet	All

MERCRUISER INBOARD ENGINES (MIE)	
Model	**Serial Number**
MIE 198	All
MIE 225 (Ford)	3750508 and Above
MIE 228	4931099 and Below
MIE 233	All
MIE 255 (Ford)	3839488 and Above
MIE 255 (G.M.)	4924564 and Below
MIE 330	4890179 and Below
MIE 350	All

TRANSOM ASSEMBLY AND STERN DRIVE UNITS	
Model	**Serial Number**
MC 120/140	3780850 - 4893634
MC 165	3780850 - 4890459
MC 470	4893834 and Below
MC 888	3784375 and Above
MC 225 S	All
MC 233	All
MC 898/228	4898729 and Below
MC 250	All
MC TR	3787240 - 5009866
MC TRS	4895289 and Below
MC Jet Drive	All

Notice to Users of This Manual

This service manual has been written and published by the service department of Mercury Marine to aid our dealers' mechanics and company service personnel when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures of these products, or like or similar products manufactured and marketed by Mercury Marine. That they have been trained in the recommended servicing procedures of these products which includes the use of mechanics common hand tools and the special Mercury Marine or recommended tools from other suppliers.

We could not possibly know of and advise the service trade of all conceivable procedures by which a service might be performed and of the possible hazards and/or results of each method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a service procedure and/or tool, which is not recommended by the manufacturer, first must completely satisfy himself that neither his nor the product's safety will be endangered by the service procedure selected.

All information, illustrations and specifications contained in this manual are based on the latest product information available at time of publication.

It should be kept in mind, while working on the product, that the electrical system and ignition system is capable of violent and damaging short circuits or severe electrical shocks. When performing any work where electrical terminals could possibly be grounded or touched by the mechanic, the battery cables should be disconnected at the battery.

Any time the intake or exhaust openings are exposed during service they should be covered to protect against accidental entrance of foreign material which could enter the cylinders and cause extensive internal damage when the engine is started.

It is important to note that, during any maintenance procedure, replacement fasteners must have the same measurements and strength as those removed, whether metric or customary. (Numbers on the heads of the metric bolts and on surfaces of metric nuts indicate their strength. Customary bolts use radial lines for this purpose, while most customary nuts do not have strength markings. Mismatched or incorrect fasteners can result in damage or malfuction, or possibly personal injury. Therefore, fasteners removed should be saved for re-use in the same locations whenever possible. Where the fasteners are not satisfactory for re-use, care should be taken to select a replacement that matches the original.

Replacement Parts

⚠WARNING

Electrical, ignition and fuel system components on MerCruiser Engines and Stern Drives are designed and manufactured to comply with U.S. Coast Guard Rules and Regulations to minimize risks of fire or explosion.

Use of replacement electrical, ignition or fuel system components, which do not comply to these rules and regulations, could result in a fire or explosion hazard and should be avoided.

When servicing the electrical, ignition and fuel systems, it is extremely important that all components are properly installed and tightened. If not, any electrical or ignition component opening would permit sparks to ignite fuel vapors from fuel system leaks, if they existed.

Engine Mechanical Components

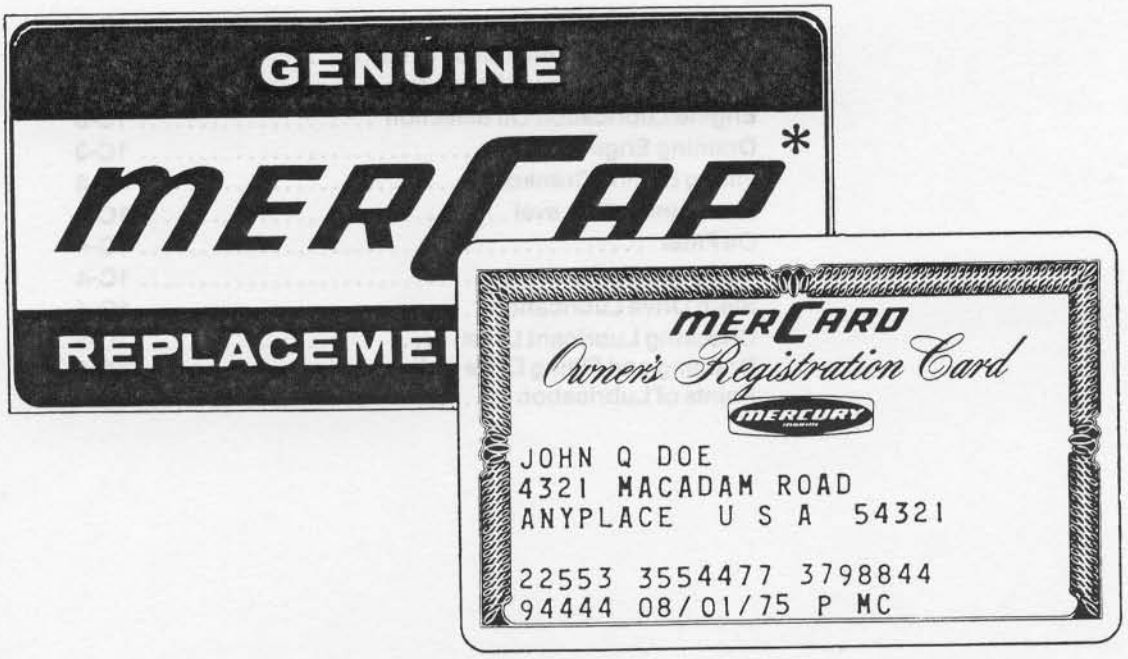
Many of the engine mechanical components are designed for marine applications. Unlike automotive engines, marine engines are subjected to extended periods of heavy load and wide-open-throttle operation, therefore, require heavy-duty components. Special marine engine parts have design and manufacturing specifications which are required to provide long life and dependable performance. Marine engine parts also must be able to resist the corrosive action of salt or brackish water that will rust or corrode standard automotive parts within a short period of time.

Failure to use recommended Quicksilver service replacement parts can result in poor engine performance and/or durabiltiy, rapid corrosion of parts subjected to salt water and possibly complete failure of the engine.

Use of parts other than recommended service replacement parts will void the warranty on those parts which are damaged as a result of the use of other than recommended parts.

GENERAL INFORMATION

MERCRUISER Section 1



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SECTION 1 - GENERAL INFORMATION

MerCruiser

PART A - GENERAL INFORMATION

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MERCURY MARINE

A BRUNSWICK COMPANY

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GENERAL INFORMATION

HOW to USE THIS MANUAL

This comprehensive overhaul and repair manual is designed for mechanics to use as a reference guide for MerCruiser engines and drive units with Serial No. 3750508 and above.

The manual is divided into SECTIONS which represent major components and systems. Following are the SECTIONS which compose this manual:

Section	Section Heading
1	General Information
2	Removal, Installation and Alignment
3	Electrical Systems
4	Fuel Systems
5	Engine
6	Drive Systems
7	Accessories
8	Specifications
9	Tools
10	Troubleshooting

SECTIONS are separated by dividers (heavier color paper) which enable the user to quickly locate any desired SECTION. A table of contents, which lists major subjects and page numbers, is printed on the reverse side of each SECTION divider.

The SECTIONS are further divided into PARTS. Each PART has a colored title page which is the same color as the SECTION divider. An index for the particular PART is printed on the title page.

NOTE: To find the subject in which you are interested, turn directly to the "Table of Contents" and "Index".

EXAMPLE: To find pinion gear shim information in MerCruiser 225II-TR gear housing, first turn to the "MerCruiser Service Manual Outline" (located in front of manual). Find the Section Number pertaining to the subject of interest, which would be "Section 6, Drive Systems".

Then, Section 6, "Table of Contents" tells you that 225II-TR Drive is outlined in Part B.

Finally, Part B "Index" is broken down in detail. Pinion gear shimming would be under:

Page

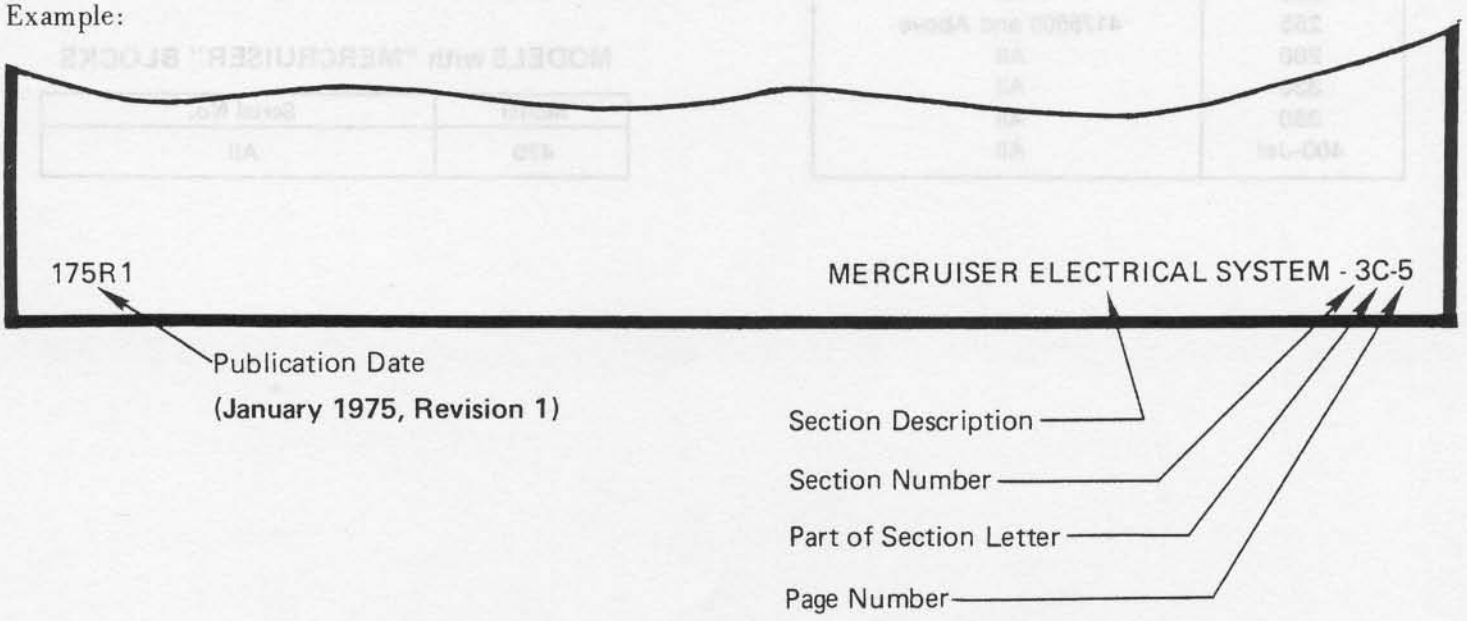
Gear Housing Reassembly . . . . . .
Shimming (Pinion Gear) 6B-9

By using these guide sheets, you can quickly find that MerCruiser 225II-TR pinion gear shimming is in Section 6 - Part B - Page 9.

PAGE NUMBERING

Two number groups appear at the bottom of each page. The example, below, is self explanatory.

Example:



DIRECTIONAL REFERENCES

Front of boat is bow; rear is stern. Starboard side is right side; port side is left side. In this maintenance manual, all directional references are given as they appear when viewing boat from stern, looking toward bow. (Figure 1)

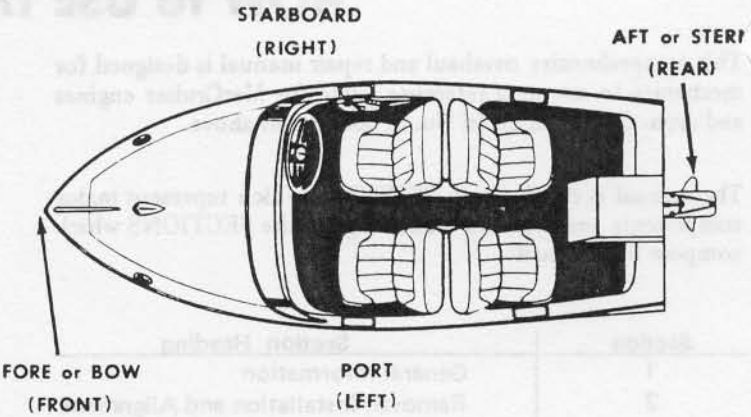


Figure 1. Directional Reference

ENGINE ROTATION TERMINOLOGY

Engine rotation is the direction (left-hand or right-hand) of rotation of the crankshaft, as observed from the transmission or drive unit end of the engine.

All MerCruiser stern drive engines are left hand (counter-clockwise) rotation. Inboard models may be either left or right hand rotation.

Do not rely on propeller rotation, as it is not necessarily the same as engine rotation.

ENGINE IDENTIFICATION

MODELS with "GM" ENGINE BLOCK

Model	Serial No.
120	All
140	All
165	All
898	All
228	All
250	All
255	4175500 and Above
280	All
330	All
350	All
400-Jet	All

MODELS with "FORD" ENGINE BLOCK

Model	Serial No.
888	All
225	All
225-S	All
233	All
255	4175499 and Below

MODELS with "MERCRUISER" BLOCKS

Model	Serial No.
470	All

ENGINE SERIAL NUMBER LOCATION

IMPORTANT: Serial numbers are the manufacturer's key to numerous engineering details applicable to the engine. When ordering parts, accessories and tools, or when corresponding with the manufacturer or dealer in regard to service matters, always specify engine serial number.

MERCRUISER 120-140-165

Serial number is located on rear right side of engine block above starter motor. (Figure 2)

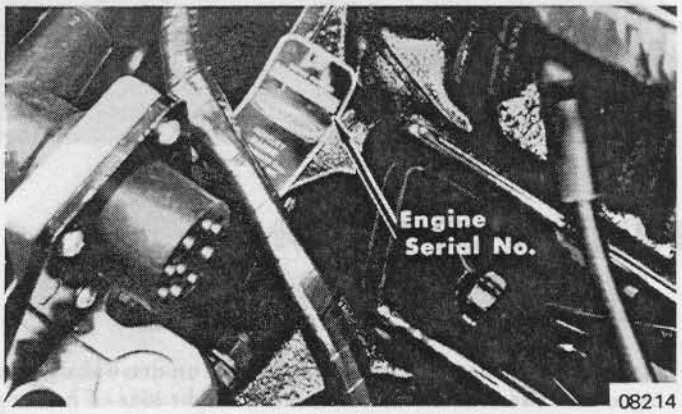


Figure 2. MerCruiser Serial No. Location

MERCRUISER 888 and 225-S

Serial number is located on rear top of cylinder block between intake manifold and flywheel housing. (Figure 3)

Figure 3. MerCruiser Serial No. Location

MERCRUISER 233, 225 II-TR and 255 II-TR and 255 II-TRS with Serial No. 4175499 and Below

Serial number is located at rear of engine on end of cylinder head. (Figure 4)

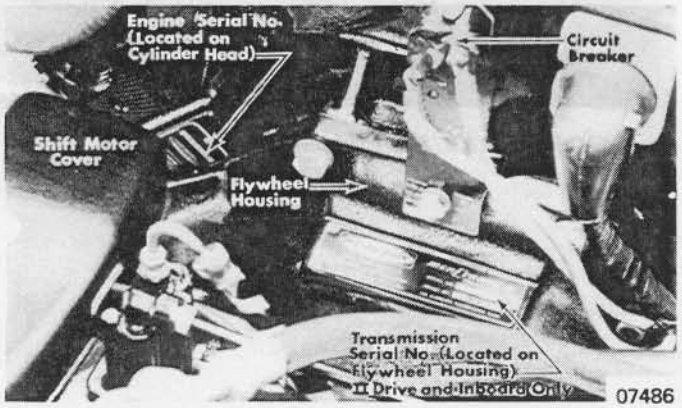


Figure 4. MerCruiser Serial No. Location

MERCRUISER INBOARD ENGINES 255 (Serial No. 4175500 and Above), 330, 350 and 400 SERIES JET

Serial number is located at rear of engine on flywheel housing. (Figure 5)

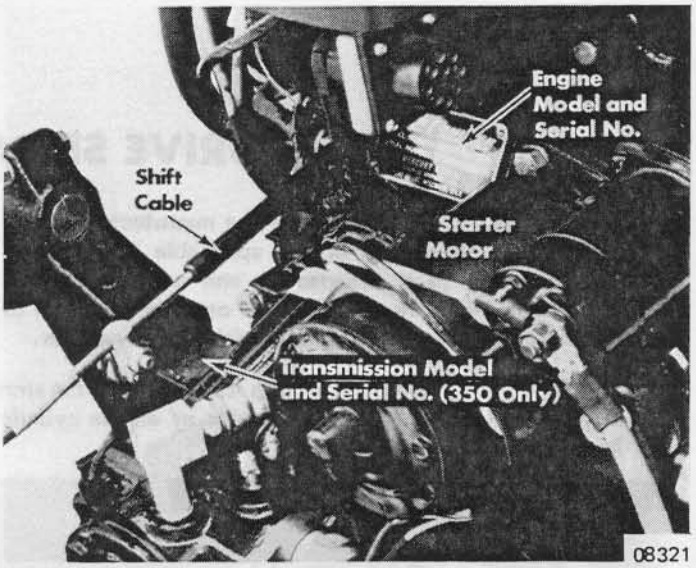


Figure 5. MerCruiser Serial No. Location

MERCRUISER 470

Serial number is located on front left side of engine next to heat exchanger.

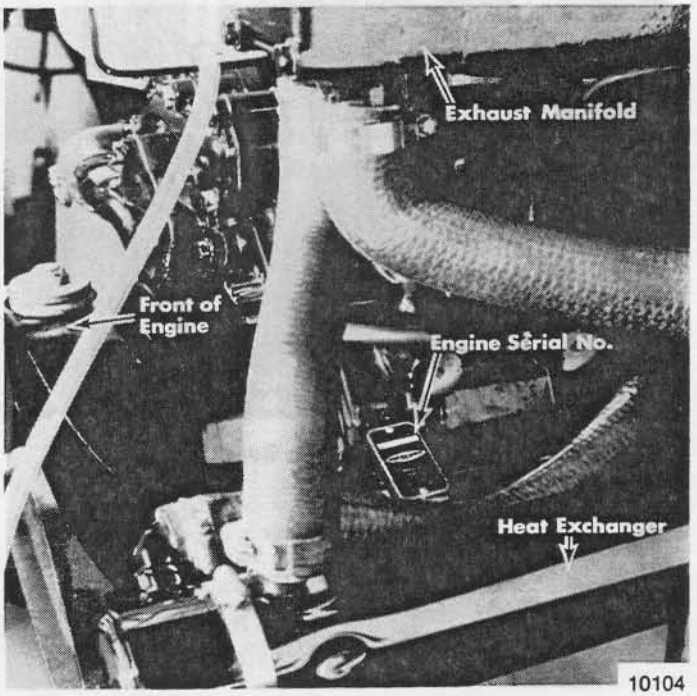


Figure 6. MerCruiser 470 Serial No. Location

MERCRUISER 898, 228, 228-TR, 250 (Serial No. 4657551 and Above), 280-TRS, 330-TR, 330-TRS

Serial number is located on rear right side of engine block above starter motor. (Figure 7)

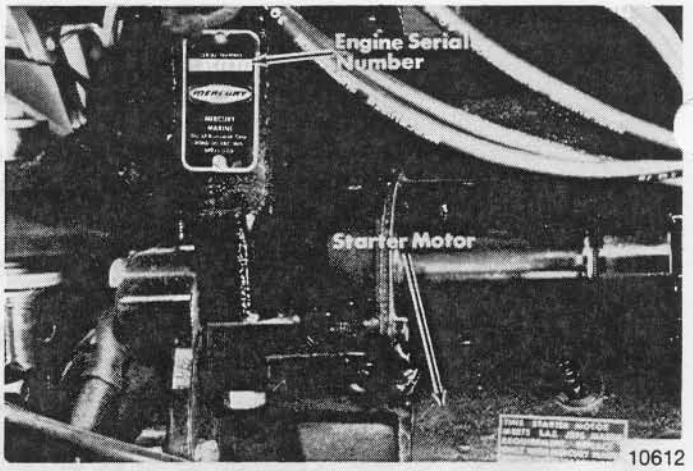


Figure 7. MerCruiser Serial No. Location

STERN DRIVE SERIAL NUMBER LOCATION

IMPORTANT: Serial numbers are the manufacturer's key to numerous engineering details applicable to the unit. When ordering parts, accessories and tools, or when corresponding with the manufacturer or dealer in regard to service matters, always specify stern drive serial number.

NOTE: A pressure-sensitive decal is enclosed with the stern drive. Decal should be placed on side of engine cylinder head rocker cover.

Figure 1. MerCruiser I-Drive Serial No. Location

MERCRUISER I-DRIVE

Stern drive unit serial number is stamped on drive shaft housing under MerCruiser decal on left or right side of housing. (Figure 2) Serial number also is on the decal on rear of drive shaft housing (or side of housing on some earlier models).

MERCRUISER II-TR and II-TRS

Stern drive unit serial number is embossed on the MerCruiser decal (located on left or right side of drive unit). This number also is stamped on drive shaft housing, directly under MerCruiser decal. (Figure 2)

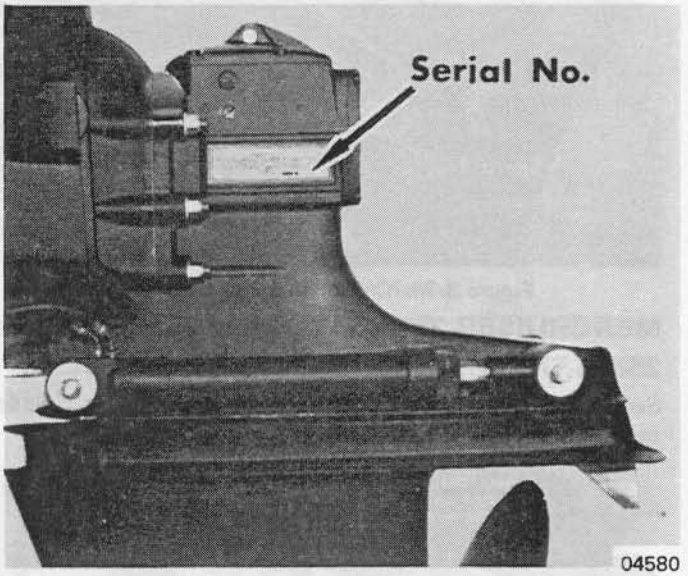


Figure 2. MerCruiser II-TR and II-TRS

FLUSHING COOLING SYSTEM

(For Additional Cooling System Information, See Section 7, Part 'D'.)

MERCRUISERS with WATER PUMP LOCATED in DRIVE UNIT

NOTE: When engine is operated in salt or silt water, it is recommended to flush engine with fresh water periodically and before storage.

CAUTION: Engine must be operated while flushing. To prevent damage to water pump impeller, attach a Flush-Test Device (C-73971A1) directly over intake holes in gear housing strut to provide cooling water at this point. (Figure 1) DO NOT OPERATE above idle speed while flushing with Flush-Test Device. See your local dealer for this device.

V-8 I-Drive models with FRESH WATER COOLING are equipped with seawater pump (located on engine) in addition to seawater pump in drive unit. Cooling water MUST BE supplied to BOTH pumps to prevent damage to water pumps' impellers.

SAFETY WARNING: When flushing, be certain that area in vicinity of propeller is clear and that no person is standing nearby, to avoid possible injury. It is advisable to remove propeller as a precautionary measure.

1. Install Flush-Test Device. Connect garden hose between it and water tap.
2. Partially open water tap. DO NOT use full city water pressure.

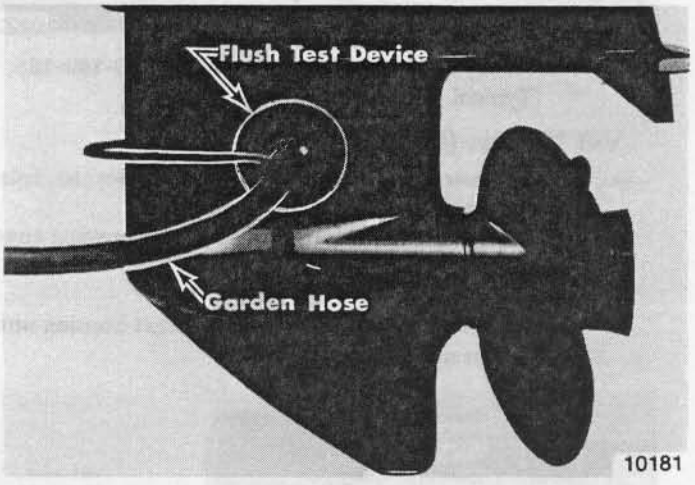


Figure 1. Flush Test Device

3. Shift into neutral gear and run engine at normal idle to circulate water until engine reaches normal operating temperature. Watch water temperature gauge to prevent overheating. Flush until discharged water is clear, THEN STOP ENGINE.
4. Close water tap and remove Flush-Test Device.

MERCRUISERS with ENGINE DRIVEN PICKUP WATER PUMP

NOTE: When engine is operated in salt water, flush it with fresh water periodically and before storage. If engine is flushed while boat is in water, water intake must have a seawater cock installed between water pickup and pump inlet.

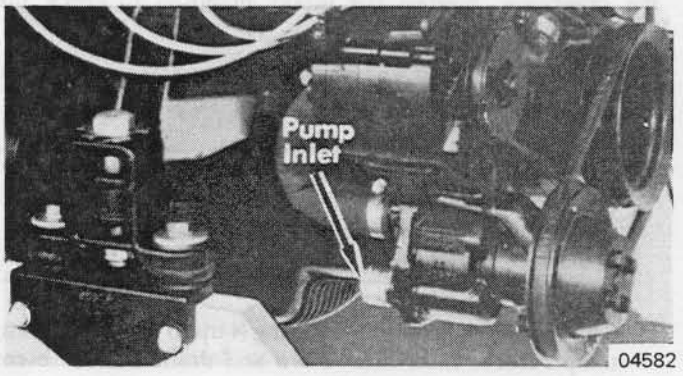


Figure 2. Seawater Pump Inlet - Typical

1. Close seawater cock (if flushed while boat is in water).
2. Remove hose clamp and hose from water pump inlet.

CAUTION: Do not operate engine without cooling water flowing through water pump, or neoprene water pump impeller will become damaged.

V-8 I-Drive models with FRESH WATER COOLING are equipped with seawater pump (located on engine) in addition to seawater pump in drive unit. Cooling water MUST BE supplied to BOTH pumps to prevent damage to water pumps' impellers.

SAFETY WARNING: When flushing, be certain that area in vicinity of propeller is clear and that no person is standing nearby, to avoid possible injury. It is advisable to remove propeller as a precautionary measure.

3. Connect length of hose to pump inlet and city water tap. Partially open tap. DO NOT use full city water pressure.
4. Place remote control handle in neutral position and start engine. Be sure that no one is near propeller. Operate engine at normal idle in neutral gear to circulate water until engine reaches normal operating temperature.
5. Check that water is being discharged out exhaust outlets and watch water temperature gauge on instrument panel to prevent overheating.
6. Allow engine to run until discharged water is clear.
7. Stop engine and remove flushing hose. Fasten water intake line securely to pump inlet with hose clamp. (Figure 2)
8. Open seawater cock.

WINTER STORAGE - MARINE ENGINES

Cylinder blocks suffer horizontal cracks when water freezes in the block. These freeze cracks are caused by failure to drain the cylinder block and exhaust manifold for winter storage in anticipation of freezing weather. Four and 6-cylinder blocks crack on sides of the engine, just below the core plugs or along the upper edge below the cylinder head.

Eight-cylinder blocks usually crack in the area near the hydraulic lifters or below the intake manifold in the valley of the block. If freezing failure is indicated or water is found in the crankcase, remove the intake manifold to check these areas.

NOTE: For closed cooling system maintenance, refer to Section 7D "Cooling".

CAUTION: Do not operate engine without cooling water flowing through water pump(s), or water pump(s) will be damaged. See "Flushing Cooling System", preceding.

1. Run engine sufficiently to bring it up to normal operating temperature, then shut down and drain crankcase completely and remove oil filter.
2. Install new oil filter, and refill crankcase with fresh SAE 20 SE oil and add one pint (473ml) can of Quicksilver 4-Cycle Engine Oil Supplement.
3. Shut gasoline supply off at fuel tank.
4. Restart engine and operate for a few minutes at fast idle (800 to 1200 RPM) to be sure that new oil is being well-circulated and that new oil filter cartridge is properly sealed. Stop and recheck oil level to be sure that level is still at "FULL" mark on dipstick. Add oil if necessary.

WARNING: Be sure engine compartment is well ventilated -- and that there are no gasoline vapors present during this operation -- to prevent a potential fire hazard.

5. Remove flame arrestor and fog internal surfaces of induction system by restarting engine and running at fast idle (800 to 1200 RPM) while slowly pouring Quicksilver Storage Seal (C-92-54778) or, if not available, pour approximately one cup of SAE 20 SE oil into carburetor during the time that the engine is running gasoline out of the carburetor, fuel pump and fuel lines. Stall engine by pouring last 2 oz. (60ml) of oil rapidly into carburetor.
6. Replace fuel filter.
7. Drain all gasoline from fuel tank.
8. Release and inspect all drive belts. Replace if necessary. Reinstall in a loose position.
9. Drain cooling system, carefully following instructions in Section 7, Part 'D', under "Draining Instructions."
10. Remove spark plugs and squirt one oz. (30ml) of Quicksilver Storage Seal or SAE 20 SE oil into each cylinder. Remove coil lead from distributor cap and ground lead. With spark plugs removed, crank engine for at least 15 seconds with starter to assure a good coating of oil on cylinder walls. Remove excess oil from around spark plug holes and lightly lubricate spark plug threads.
11. Service spark plugs as explained under "Tune Up", Section 1, Part 'B'. Reinstall spark plugs and coil lead.
12. For additional assurance against freezing and rust, it is recommended that the cooling system be filled with a solution of permanent anti-freeze and water. Solution should be mixed to the anti-freeze manufacturer's recommended proportion for the lowest temperature to which engine will be exposed while in storage.

Fill cooling system with anti-freeze as follows:

MerCruiser 120-140-165 (Figure 1)

(For 470, See Section 7, Part 'D'.)

a. Remove water distribution block cover and thermostat.
b. Remove hose from front end cap on manifold.
c. Pour anti-freeze solution into opening in water distribution block until cylinder block, head and manifold are full.
d. Reinstall thermostat, using a new gasket, and connect hose to manifold end cap.

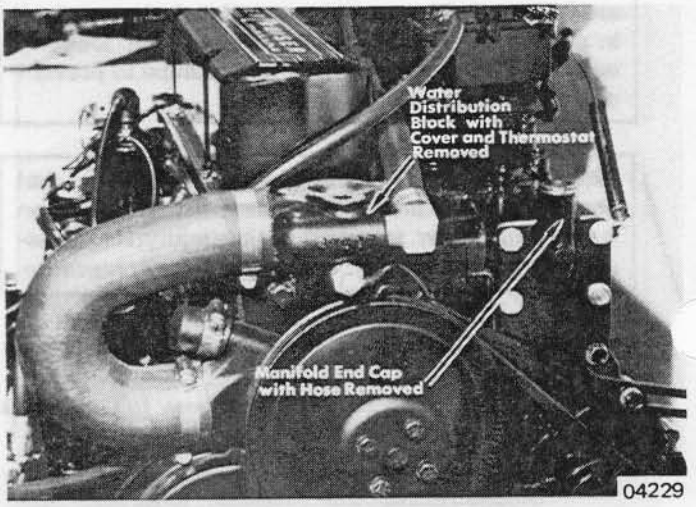


Figure 1. Filling with Anti-Freeze - Models 120-140-165, Typical

V-8 Models (Figure 2 or 3)

a. Loosen hose clamps, which fasten hoses to front manifold end caps, and remove hoses.
b. Remove screws, which fasten thermostat housing cover to housing, and remove cover.
c. Remove thermostat from housing.
d. Pour anti-freeze solution into thermostat housing until level comes up to top.

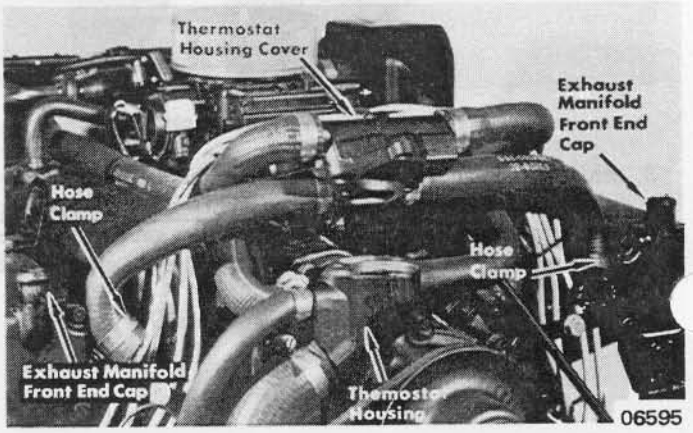


Figure 2. Filling with Anti-Freeze-"Ford" Type V-8's, Typical

e. Pour anti-freeze solution into opening on each manifold end cap until level comes up to top of end cap.
f. Place new gasket on thermostat housing and install thermostat and cover.
g. Connect hoses to manifold end caps.

13. Inspect all hoses for cracks and deterioration and service them as required.
14. Remove and clean flame arrestor and reinstall.
15. Remove battery and service as specified by manufacturer. Clean and service battery supports, containers and cables as required. (See "Winter Storage of Batteries," following.)
16. Remove valve rocker arm covers. If condensation has occurred in rocker arm cover compartment, carefully wipe away all traces of oil-water mixture, then liberally coat valve mechanism and inside of cover with Quicksilver Storage Seal (C-92-54778) or SAE 20 SE oil. Reinstall covers, with new gaskets.
17. Clean crankcase ventilating system, as explained under "Cleaning Crankcase Ventilating System".
18. Clean outside of engine and spray Quicksilver Rust and Corrosion Preventive (C-92-63260) on exterior surfaces of engine or wipe down with rag to leave a very light coating of Storage Seal or SAE 20 SE oil on exterior surfaces of engine.

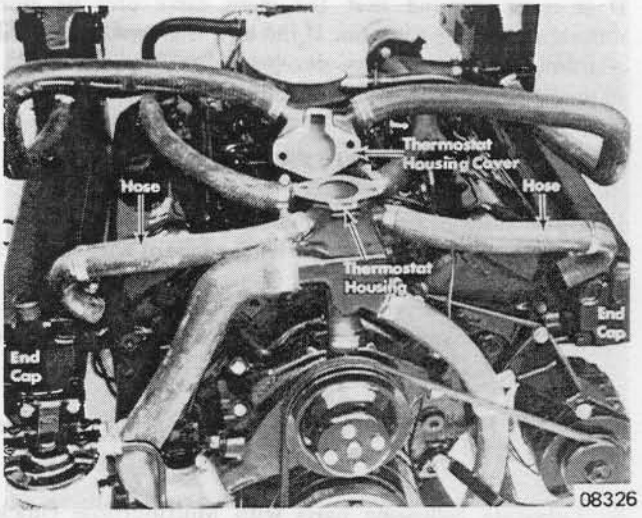


Figure 3. Filling with Anti-Freeze - "GM" Type V-8's, Typical

WINTER STORAGE of BATTERIES

Battery companies are not responsible for battery damage either in winter storage or in dealer stock if the following instructions are not complied with:

1. Remove battery from its installation as soon as possible and remove all grease, sulfate and dirt from top surface by turning a hose on top of battery. Be sure, however, that vent caps are tight beforehand, and blow off all excess water thoroughly with compressed air. Check water level, making sure that plates are covered.
2. When adding distilled water to battery, be extremely careful not to fill more than 3/16" (4.8mm) above perforated baffles inside battery. Battery solution or electrolyte expands from heat caused by charging. Overfilling battery will cause electrolyte to overflow (if filled beyond 3/16" above baffles).
3. Grease terminal bolts well with cup grease or Multipurpose Lubricant (C-92-63250) and store battery in COOL-DRY place. Remove battery from storage every 30-45 days, check water level and put on charge for 5 or 6 hours at 6 amperes. DO NOT FAST CHARGE.
4. If specific gravity drops below 1.240, check battery for reason and recharge. When gravity reaches 1.260, discontinue charging. To check specific gravity, use a hydrometer, which can be purchased locally.
5. Repeat preceding charging procedure every 30-45 days, as long as battery is in storage, for best possible maintenance during inactive periods to insure a good serviceable battery in spring. When ready to place battery back in service, remove excess grease from terminals (a small amount is desirable on terminals at all times), recharge again as necessary and reinstall in your equipment.

SAFETY WARNING: Hydrogen and oxygen gases are produced during normal battery operation or charging. Sparks or flame can cause this mixture to ignite and explode, if they are brought near the vent openings. Sulphuric acid in battery can cause serious burns, if spilled on skin or in eyes. Flush or wash away immediately with clear water.

RETURNING ENGINE to SERVICE

1. Install battery, being sure that it is in a fully-charged condition. Clean and lightly lubricate terminals.
2. Drain anti-freeze (except 470) if you desire to save it.
3. Check cooling system to be sure all hoses are properly attached.
4. Readjust drive belt tension.
5. Check engine alignment.
6. Check engine, transmission, stern drive unit, Power Steering and Power Trim pump oil levels.
7. Check engine mount fasteners.
8. Be sure that drain plugs are installed and drain valves are closed.

WINTER STORAGE - STERN DRIVE UNITS

It is recommended that the stern drive unit be stored in normal operating position. If the unit is stored in the "tilt-up" position, the bellows may develop a "set" which would result in premature failure when the unit is returned to service.

MERCRUISER I-DRIVES

1. Open water drain holes (one located in gear housing and 2 in drive shaft housing) and use a piece of wire to check that they are open.
2. Drain stern drive lubricant and refill with Super-Duty Gear Lubricant (C-92-52645). Refer to "Draining and Filling Drive Unit", Section 1C.

   NOTE: For location of lubrication points, refer to Section 1C.

3. Lubricate following parts with Multipurpose Quicksilver Lubricant (C-92-63250).
   a. Ride-Guide steering cable end.
   b. Pivot socket of steering arm.
   c. Universal joint shaft splines and engine coupling splines.
   d. Drive unit upper and lower pivot pins.
   e. Gimbal bearing, if applicable.
   f. Power Steering control valve, if applicable.
4. Lubricate universal joint bearings with Universal Joint Lubricant (C-92-58299).
5. Remove propeller, apply Perfect Seal (C-92-34227) to propeller shaft and reinstall.
6. Lubricate drive unit hinge pins with Anti-Corrosion Grease (C-92-63290).
7. Check bellows condition. Replace if necessary.
8. Check water pump impeller. Replace if impeller is worn, hardened or set.
9. Check condition of drive unit painted surfaces. Clean and paint metal surfaces that have become exposed. Spray stern drive exterior with Corrosion and Rust Preventive (C-92-63260).
10. At this time, before installing drive unit, check engine alignment as explained in Section 2.

MERCRUISER II-TR and II-TRS

1. Drain and refill stern drive unit with Super-Duty Quicksilver Gear Lubricant (C-92-68617) before storage. Refer to "Draining and Filling Drive Unit" Section 1, Part C.

   NOTE: For location of lubrication points, refer to Section 1C.

2. Lubricate the various MerCruiser Stern Drive components with Multipurpose Lubricant (C-92-63250) thru grease fittings:
   a. Ride-Guide steering cable end next to coupler nut.
   b. Gimbal housing upper and lower pivot pin.
   c. Transmission output housing bearing.
   d. Power Steering control valve.
3. Lubricate universal joint bearings with Universal Joint Lubricant (C-92-58229).
4. Lubricate drive unit hinge pins with Anti-Corrosion Grease (C-92-63290).
5. Check bellows condition and replace if necessary.
6. Before installing drive unit, check engine alignment as explained in Section 2.
7. Remove propeller, apply Perfect Seal (C-92-34227) to propeller shaft and reinstall propeller. (Refer to "Drive Unit" Section 6)
8. Wipe exterior of stern drive unit clean and spray with Corrosion and Rust Preventive (C-92-63260).
9. Store stern drive unit in the normal operating position. The universal joint bellows may develop a "set", if unit is stored in a tilted-up position, and result in bellows failure when unit is returned to service.

POWER TRIM OPERATION

CAUTION: When using Power Trim on some boats, operation at extreme "IN" or "OUT" positions greatly increases steering torque, and steering becomes difficult. Stern drive unit should be trimmed to a safe operating angle to provide easy steering.

Two different style controls (panels) are used to actuate Power Trim (both accomplish the same result). The 3-switch control utilizes 3 in-line push button switches. (Figure 1) The new style 2-switch control uses only one push button switch and one toggle switch (Figure 2). Operate Power Trim only in neutral and forward gear.

OPERATING 3-SWITCH CONTROL

1. Trimming Out: Press "Up/Out" button (Figure 1) until drive unit moves to properly trim boat. Cutout switch will stop drive unit from moving out beyond gimbal ring flanges.
2. Trimming In: Press "In" button (Figure 1) until drive unit moves to properly trim boat or until drive reaches end of downward travel.
3. Trailering: Raise drive unit for trailering or launching by shifting control to "Neutral" or "Forward" and pressing "Up" and "Up/Out" buttons simultaneously. (Figure 1) Push trim "In" button to lower drive unit.
4. Shallow Water Operation: Drive unit may be raised for shallow water operation by using trailering buttons ("Up" and "Up/Out"), however, do not exceed an engine speed of 1200 RPM.

CAUTION: Do not run at high speed with drive unit out beyond gimbal ring flanges, as drive unit will have no side thrust supports. Exercise caution when operating at extreme angles in shallow water.

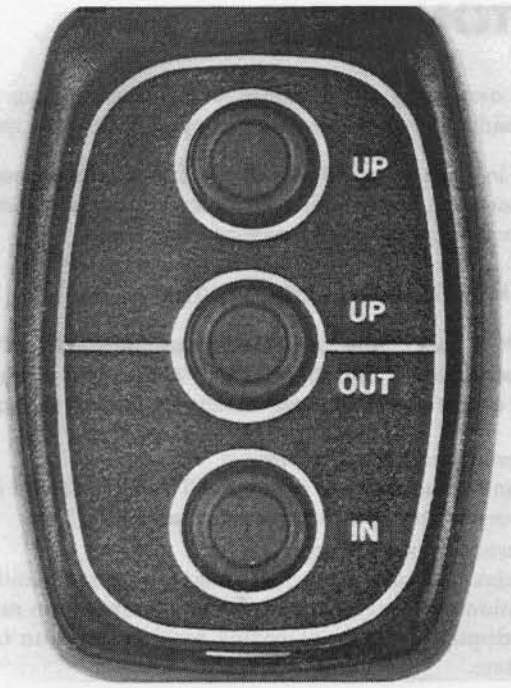


Figure 1. Three-Switch Control Panel

Figure 2. Toggle Switch Control

OPERATING 2-SWITCH CONTROL

1. Trimming Out: Press up on toggle switch (Figure 2) until drive unit moves to properly trim boat. Cutout switch will stop drive unit from moving out beyond gimbal ring support flanges.
2. Trimming In: Press down on toggle switch (Figure 2) until drive unit moves to properly trim boat or until drive reaches end of downward travel.
3. Trailering: To raise drive unit for trailering or launching, move shift control to "Neutral" or "Forward" position and press the trailering button. (Figure 2) Push down on toggle switch to lower drive unit.
4. Shallow Water Operation: Drive unit may be raised for shallow water operation by using trailering button, however, do not exceed an engine speed of 1200 RPM.

CAUTION: Do not run at high speed with drive unit out beyond gimbal ring flanges, as drive unit will have no side thrust supports. Exercise caution when operating at extreme angles in shallow water.

NOTE: If switch of either control is not released after drive unit reaches end of upward travel, an overload cutout switch will open and pump motor will stop. To prevent cutout from opening, it is recommended that switch(s) be released when drive unit reaches end of upward travel. If cutout should open, do not operate switch(s) for approximately one minute. After this period of time, cutout will close and unit may be operated.

INDICATOR READJUSTMENT

If unit was fully extended into the "Up" trailer position, it may be necessary to reset the indicator by operating "In" button (or push down on toggle). Hold until indicator needle (Figure 3) reaches bottom of green arc.

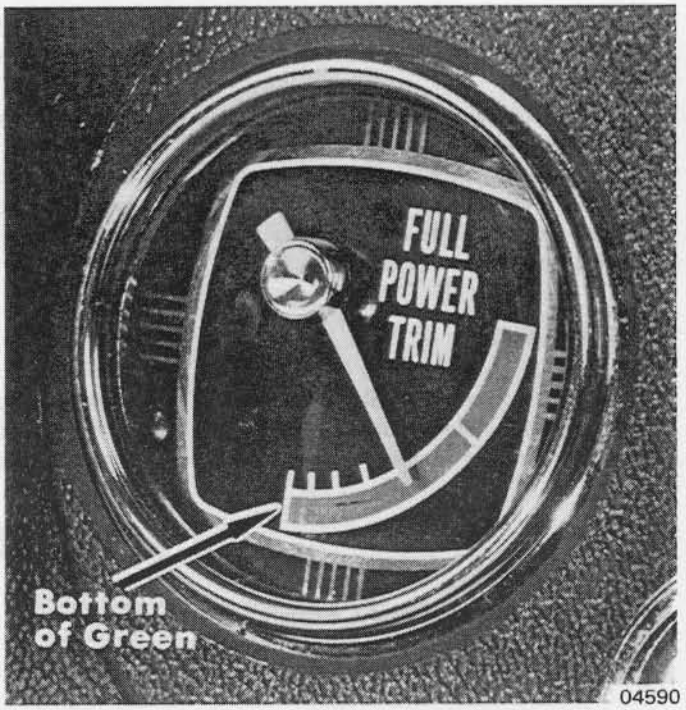


Figure 3. Indicator Readjustment

PRE-IGNITION and DETONATION

PRE-IGNITION

Pre-ignition is abnormal fuel ignition, caused by combustion chamber hot spots. Control of the start of ignition is lost, as combustion pressure rises too early, causing power loss and rough running. The upward motion of the piston is opposed by the pressure rise. This can result in extensive damage to the internal parts from the high increase in combustion chamber temperature. (Figure 1)

Figure 1. Pre-Ignition Damage

PRE-IGNITION CAUSES

1. Hot spots in the combustion chamber from glowing deposits (due in turn to the use of improper oils and/or fuels).
2. Overheated spark plug electrodes (improper heat range or defective plug).
3. Any other protuberance in the combustion chamber, such as an overhanging piece of gasket, an improperly seated valve or any other inadequately cooled section of material which can serve as a source.

DETONATION

Detonation, commonly called "fuel knock", "spark knock" or "carbon knock", is abnormal combustion of the fuel which causes the fuel to explode violently. The explosion, in turn, causes overheating or damage to the spark plugs, pistons valves and, in severe cases, results in pre-ignition. (Figure 2)

Use of low octane gasoline is one of the most common causes of detonation. Even with high octane gasoline, detonation could occur if engine maintenance is neglected.

OTHER CAUSES of DETONATION

IMPORTANT: See "Fuel Recommendations" in "Tune-Up Specifications", Section 8, Part 'A'. Use of improper fuels will cause engine damage and poor performance.

1. Over-advanced ignition timing.
2. Lean fuel mixture at or near full throttle (could be caused by carburetor or leaking intake manifold).
3. Cross-firing spark plugs.
4. Excess accumulation of deposits on piston and/or combustion chamber (results in higher compression ratio).
5. Inadequate cooling of engine by deterioration of cooling system.

Engine failures, which result from the foregoing conditions, are beyond the control of Mercury Marine, therefore, no warranty will apply to failures which occur under these conditions.

Figure 2. Detonation Damage

TRIM TAB

REMOVAL and REPLACEMENT

1. Before removing trim tab, mark trailing edge location on cavitation plate and remove plug which is located directly above trim tab. (Figure 3)
2. Loosen screw, which holds trim tab, thru hole in drive housing with a 5/16 or 3/8 allen wrench.
3. Clean recess area to assure metal-to-metal contact between drive and trim tab.
4. Place trim tab in position and secure by reversing removal steps.
5. Readjust trim tab, following, if necessary.

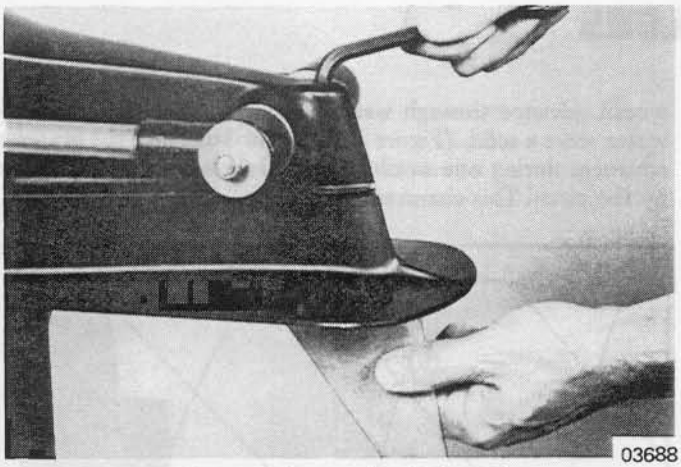


Figure 3. Removing Trim Tab

TRIM TAB ADJUSTMENT

NOTE: With Power Steering installed, trim tab should be adjusted straight back.

MerCruiser Stern Drives are equipped with an adjustable trim tab to balance "steering torque" so that the steering wheel will turn with equal ease in each direction.

Adjust trim tab as follows:

1. Operate boat at best throttle setting. Trim boat as outlined under "Power Trim Operation", in this section. Turn steering wheel to left and right, noting in which direction wheel turns more easily. With boat at rest, remove plug from drive shaft housing and loosen allen head screw. (Figure 3)
2. If steering wheel turns more easily to left, position trailing edge of trim tab to left. (Figure 4)
3. If steering wheel turns more easily to right, position trailing edge of trim tab to right. (Figure 4)
4. Tighten socket head screw securely and replace plug. (Figure 3)

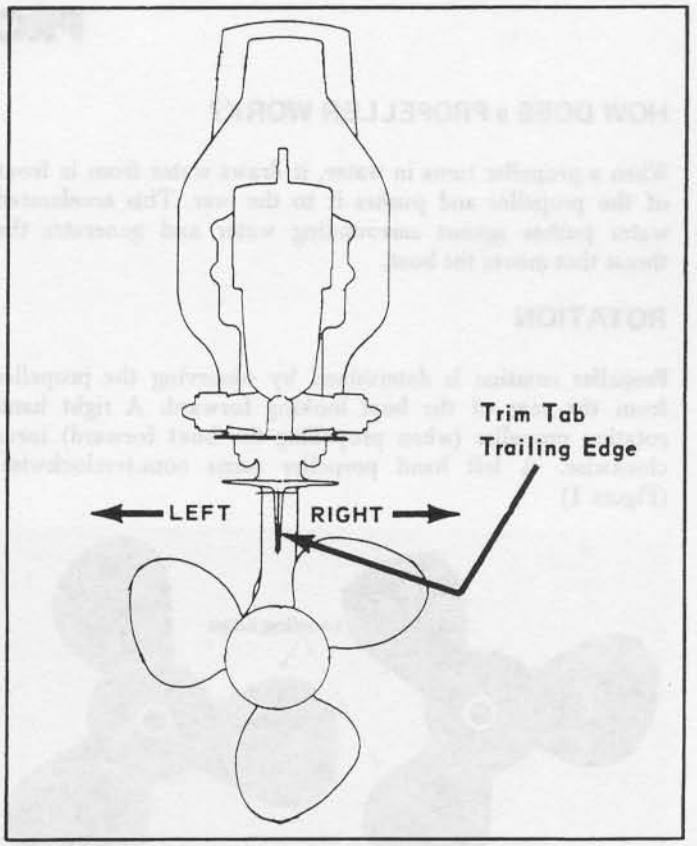


Figure 4. Trim Tab Trailing Edge

5. Operate boat to check setting. Readjust trim tab if necessary.

NOTE: When trimming-in or trimming-out, steering torque may increase even though trim tab has been adjusted properly. Trim tab will be the most effective at the boat speed and trim setting for which tab was adjusted.

MERCRUISER FUEL SYSTEM

Observe Coast Guard Regulations when installing fuel system. The following suggestions also should be followed to ensure trouble-free service.

FUEL TANK - CAUTIONS

In many cases of engine malfunction with fiberglass fuel tanks, we have found wax (used in tank construction) dissolved by the fuel and lodged in the fuel filters. This condition is difficult to detect and, although the filters may appear to be in perfect condition, fuel flow is restricted and results in a lean-out condition that can be corrected only by replacing filter elements. In other types of fiberglass fuel tanks, minute particles of fiberglass remain in the tank after construction, with subsequent clogging of fuel filters.

In addition, the fuel pickup in "built-in" or special fuel tanks may be unsuitable to handle fuel requirements to the engine, thereby causing engine malfunction.

CAUTION: Special or "built-in" fuel tanks are not approved. Exercise caution if used with MerCruiser engine.

Other causes of engine malfunctions are:

1. Fuel pickup has too small a screen or filter over end.
2. Poor joints or connections causing air leaks in fuel system.
3. Absence of large openings at reasonable location prevents proper fuel pickup installation.
4. Some types of galvanized tanks cause flaking of plating, thereby clogging fuel pickup and filters.
5. Tanks, which have been spray-painted on the inside, experience flaking which clogs pickup and filters.
6. Fuel tanks should be installed in a position below the carburetor itself when boat is at rest. If tank is located above carburetor, gravity feed could cause carburetor flooding.
7. Rocking or jostling of boat, while moored, may result in unseated inlet needle valve and cause carburetor to flood. This will allow raw fuel to enter intake manifold and combustion chambers and seep past piston rings, thus diluting crankcase oil. If this condition exists, it can be corrected only by relocating fuel tank so that fuel level in tank is below carburetor bowl when boat is at rest.

FUEL LINES - LENGTH and SIZES

1. Fuel line size MUST NOT be smaller than 5/16" (7.9mm) I.D.
2. A larger line should be used in cases where long lines, valves, manifolds and filters are used.
3. Fuel line must be installed free of stress and firmly secured to prevent vibration and/or chafing.
4. Avoid sharp bends.
5. Flex line on inlet side of fuel pump must be connected to copper line to absorb any vibration or movement caused by motor mount deflection when engine is running.

PROPELLERS

HOW DOES a PROPELLER WORK?

When a propeller turns in water, it draws water from in front of the propeller and pushes it to the rear. This accelerated water pushes against surrounding water and generates the thrust that moves the boat.

ROTATION

Propeller rotation is determined by observing the propeller from the rear of the boat looking forward. A right hand rotating propeller (when propelling the boat forward) turns clockwise. A left hand propeller turns counterclockwise. (Figure 1)

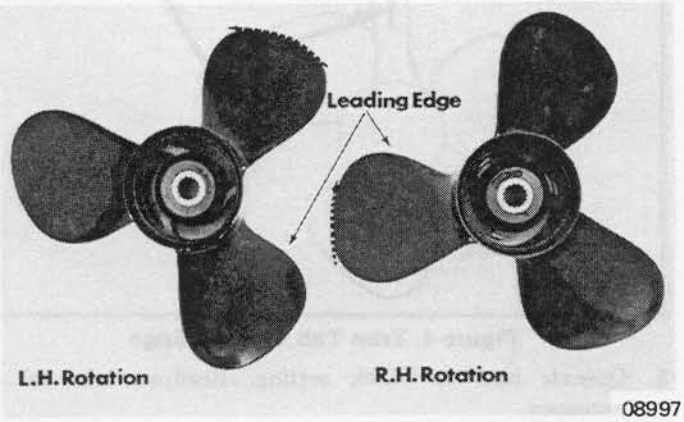


Figure 1. Right Hand and Left Hand Rotating Propeller

PROPELLER DIAMETER

Propeller diameter is measured across the circle marked out by the blade tips as the propeller is turned. (Figure 2)

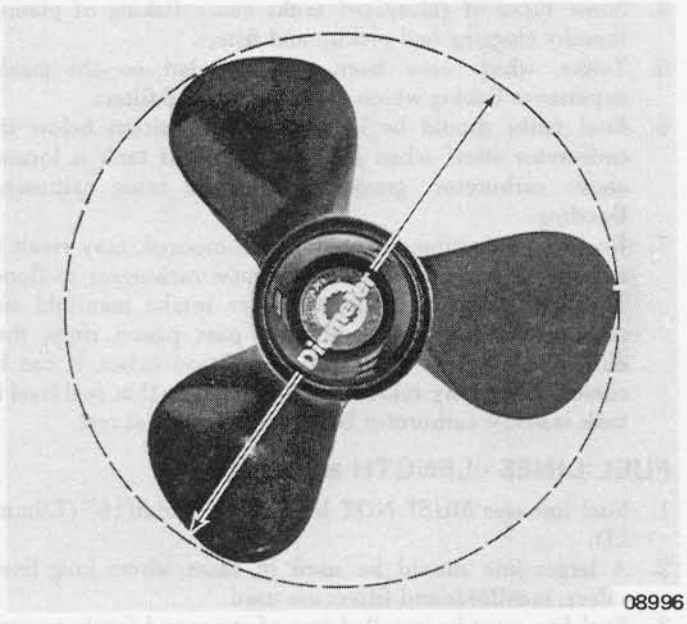


Figure 2. Propeller Diameter

PROPELLER PITCH

Propeller pitch is more easily understood if you think of the propeller as a screw. Its pitch is the distance the propeller would advance through water when rotated one revolution if water were a solid. (Figure 3) The actual distance the propeller advances during one revolution will be less than that indicated by the pitch. This characteristic is "slip".

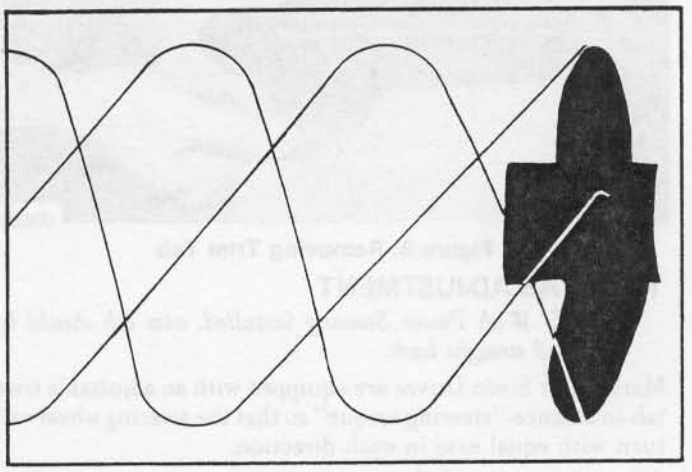


Figure 3. Propeller Pitch

PROPELLER SLIP

Propeller slip, as it affects the boatman, is the difference between actual propeller advance and calculated advance that is predicted if the propeller were a screw moving through a solid. This difference then is divided by calculated advance to obtain a percentage.

Propeller slip is often associated with efficiency. Rather, propeller slip is like the angle of attack of an airplane wing. As an airplane wing must run at some angle of attack to produce lift, so the propeller blades must cut into the water at a similar angle of attack in order to produce thrust. The most efficient (best lift to friction drag ratio) angle of attack for an airplane wing is in the 4^{o} to 6^{o} region. Similarly, the most efficient (best thrust to friction drag ratio) slip percentage is 10% to 20%. Remember, a typical propeller cannot produce thrust without the blades operating at some "angle of attack" or "slip".

CAVITATION

Cavitation is a fancy name for boiling water or water turning from its liquid state into a vapor with about the same density as air. Whereas boiling normally occurs when sufficient heat is applied to water, it also can occur when the local pressure is reduced sufficiently. Therefore, when water is deflected, not allowing water to follow contour of blade, a low pressure area may be created. If this pressure gets low enough, boiling begins. Naturally, a propeller, that is made to operate in dense water, normally will not operate correctly when a gas (air or water vapor) is mixed in with the water. The result is a speed-up in engine RPM, a loss in boat speed, vibration and pitting of the propeller blades (caused by the water vapor bubbles collapsing as they condense back to the liquid state).

CUPPED PROPELLER

A cupped propeller has the trailing edge of the blades rolled or cupped, thus greatly increasing the pitch just in that region of

the blade. A cup enables a propeller to operate still reasonably well while some air or cavitation bubbles are mixed in with the water around the propeller. This can result in higher permissible transom heights or a further kicked-out tilt position either of which (on medium to fast boats) will result in a little higher boat speed. The higher transom height reduces gearcase drag, and the greater tilt angle lifts the bow of the boat more, resulting in a more efficient boat bottom angle of attack (the same principle as the most efficient airplane wing angle of attack or propeller blade angle of attack slip). An average cup adds about ½" (12.7mm) of pitch and reduces engine speed by 200-400 RPM.

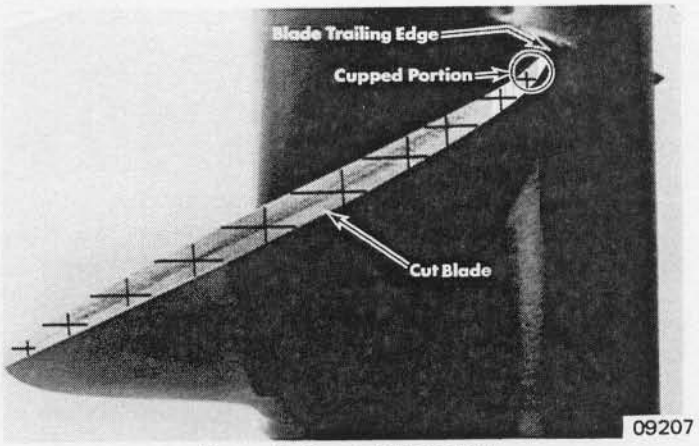


Figure 4. Cupped Propeller

TWO and THREE-BLADE PROPELLERS

Technically, 2-blade propellers are more efficient than 3-blade propellers, which in turn are more efficient than 4-blade propellers. If top speed on smooth water were the only consideration, a 2-blade propeller would be the best selection. However, if planing off a boat with a heavy load or cruising with less boat vibration or running in rough water are considerations, a 3-blade propeller is preferred. For this reason, only 3-blade propellers are recommended for use in virtually every application.

CORRECT PROPELLER?

Diameter and pitch, the two most important propeller characteristics, are measured in inches, and propeller pitch usually is stamped on the hub. If diameter also is stamped on the propeller, this number would be listed first.

Example: 15¼ x 21 = Diameter x Pitch.

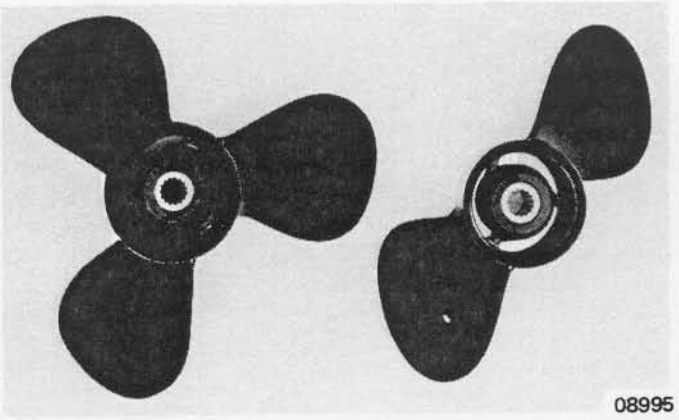


Figure 5. Two and 3-Blade Propellers

Incorrectly propped, a boat can suffer reduced top speed, poor acceleration and poor fuel economy. It even can shorten engine and/or drive life by either overloading the motor or allowing excessive RPM. Correct propellers are found in prepared charts, catalogs or Boat House Bulletins. Here, the testing has been done for you, and correct propeller sizes are listed for typical boats of various weights and styles. Also, see Section 8, Part 'D', "Propeller Recommendation Chart".

Check for the correct propeller by test running the boat, using an accurate tachometer. Basically, the correct propeller is one that turns RPM within the range recommended by the engine manufacturer at wide-open throttle. If the tachometer reads too high, use a propeller of greater pitch. If the tachometer reads too low, use a propeller of lower pitch.

Under certain operating conditions, such as overloading of a boat or pulling water skiers, it may be necessary to reduce propeller pitch to again allow the engine to turn up to its recommended RPM. By doing this, better acceleration and overall performance will result.

CAUTION: If, at any time, operating conditions change to where a boat is no longer overloaded or water skiers are no longer pulled, the original propeller should be reinstalled to prevent engine damage caused by excessive RPM.

SECTION 1 - GENERAL INFORMATION

mercruiser

PART B - TUNEUP

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MERCURY MARINE

A BRUNSWICK COMPANY

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TUNE-UP
(Conventional and Thunderbolt System)
DESCRIPTION

This section outlines procedures to follow when performing engine tuneup on MerCruiser Marine Engines and Stern Drives. To assure lasting results, it is advisable that the service technician follow a definite and thorough procedure of analysis and correction of all items which affect power, performance and economy.

The extent of engine tuneup usually is determined by the interval since the last engine service. Servicing of specific items on the engine should be performed at regular intervals, depending upon operating conditions. When major corrective action is required, refer to appropriate sections of this manual for detail information. Refer to "Troubleshooting", Section 10, for ignition system troubleshooting. Refer to "Tune-Up", Section 8, for specific data.

COMPRESSION TEST

1. Remove and ground coil high tension lead from distributor cap tower. Remove any foreign matter from around plugs by blowing away with compressed air, then remove plugs.

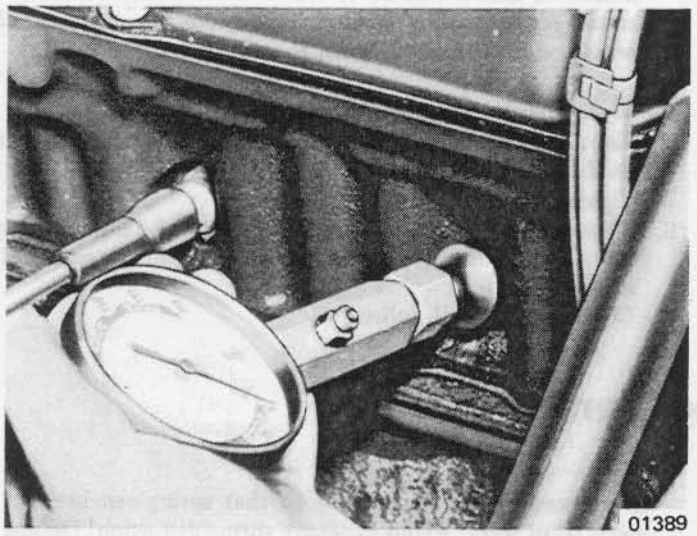


Figure 1. Checking Compression

2. Remove flame arrestor and block throttle and choke in wide open position.
3. Insert compression gauge firmly in spark plug port. (Figure 1)
4. Crank engine thru at least 4 compression strokes to obtain highest possible reading.
5. Check and record compression of each cylinder. Compression should read as indicated in tuneup "Specifications" Section 8. Variation between highest and lowest reading cylinders should be less than 20 lbs. per sq. in. (1.4kg/cm^2).
6. If one or more cylinders read low or uneven, inject a tablespoon of engine oil on top of pistons thru spark plug port. Crank engine several times and recheck compression.
7. Checking results:
   a. If compression increases, but does not necessarily reach normal, rings are worn.
   b. If compression does not improve, valves are sticking or seating poorly.
   c. If 2 adjacent cylinders indicate low compression and injecting oil does not increase compression, the cause may be a head gasket leak between cylinders with resulting engine coolant and/or oil in cylinders.

SPARK PLUGS

CONVENTIONAL TYPE

1. Inspect each plug for broken, glazed or blistered procelain and badly worn electrodes. Replace plugs which are not serviceable. Be sure that all plugs are the same make and number as listed under "Specifications" Section 8.
2. Prior to installing used plugs, file center electrode flat and adjust gap to setting with a round feeler gauge. (Figure 2)
3. Prior to installing new plugs, adjust gap to setting listed in specifications with a round feeler gauge. (Figure 2)

CAUTION: DO NOT use gaskets on spark plugs with tapered seats.

4. Wipe plug seats in cylinder head clean. Place new gaskets on used plugs (without tapered seats) and thread plugs into cylinder head. Tighten plugs with a torque wrench to "Specifications" Section 8.

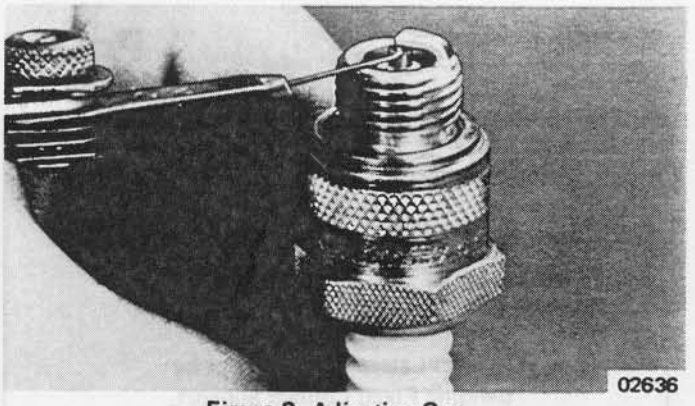


Figure 2. Adjusting Gap

IGNITION SYSTEM

1. Check spark plug leads and coil lead for abrasions or other damage. Replace leads which are not serviceable, being sure that leads are connected securely to the correct spark plugs.
2. Remove distributor cap, clean and inspect for cracks, carbon tracks and eroded electrodes. Replace cap if damage is found.
3. Check distributor centrifugal advance mechanism by turning rotor clockwise by hand as far as possible, then releasing rotor so that springs return it to its retarded position. If rotor does not return readily, distributor must be disassembled and cause for malfunction corrected.
4. Clean rotor and inspect for cracks and badly eroded electrode. Replace rotor if damage is found.

Breaker Points and Condenser Replacement or Cleaning

NOTE: Does not apply to Thunderbolt Ignition.

1. Remove distributor cap and rotor.
2. Remove breaker points and condenser.
3. Examine distributor points and clean or replace if necessary. Contact points with an overall gray color and only slight roughness or pitting need not be replaced. Replace points which are burned or badly pitted. Replace condenser when replacing points, unless sufficient test equipment is available to check for a defect.
4. Dirty contacts should be cleaned with a clean ignition point file. Do not use emery cloth or sandpaper, since particles will imbed and cause arcing and rapid burning of points.

FINDING CAUSE OF TROUBLE: Where burned or badly pitted points are encountered, ignition system, engine and/or operators' practices should be checked to determine cause of trouble so that it can be corrected. Unless condition, which causes point burning or pitting, is corrected, new points will provide no better service than the old points.

5. Clean distributor and breaker plate.
6. Place points and condenser in position and tighten hold-down screws.
7. Tighten all connections.
8. Lubricate distributor cam with a thin film of high-melting-point, non-bleeding grease or replace distributor cam shaft lubricating wick.
9. Check point dwell, following.

Points Spring Tension

1. Check distributor point spring tension (contact point pressure) with spring gauge, hooked to breaker lever at contact, and pull at 90° to breaker lever. Points should be closed (cam follower between lobes) and reading taken just as points separate for spring tension. Refer to "Specifications" Section 8.
2. If tension is not within limits, adjust by bending breaker lever spring. If pressure is excessive, it can be decreased by pinching spring carefully. To increase pressure, lever must be removed from distributor so that spring can be bent away from lever. Avoid excessive spring distortion! Do not bend with pliers.

NOTE: Excessive point pressure will cause excessive wear on points, cam and rubbing block, while weak point pressure permits bouncing or chattering which results in arcing and burning of points and an ignition miss at high speed.

Point Alignment

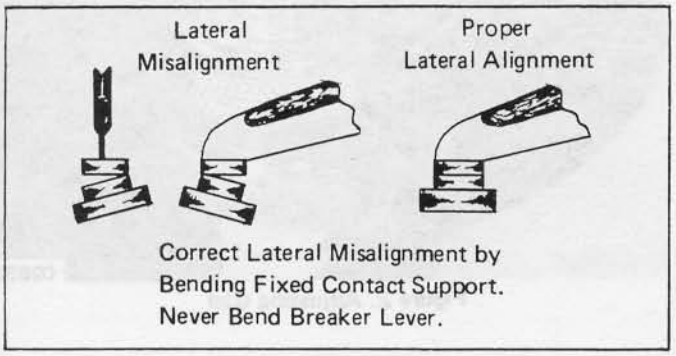


Figure 3. Alignment of Points

1. Check alignment of distributor points with points closed. (Figure 3) Align new points where necessary, but do not attempt to align used points. Instead, replace used points where serious misalignment is observed.
2. Align points by bending fixed contact support as necessary with alignment tool, if available. Do not bend breaker arm!
3. Inspect alignment of rubbing block with cam and check for a twisted arm or pivot pin if alignment is not correct. Correct contact point opening is important, particularly during starting and low speed operation. If contact points are set too close, arcing and burning will occur and cause hard starting and poor low speed performance. If points are set too wide, cam angle or dwell will be too small to

allow saturation of coil at high engine speeds and result in a weak spark. Distributor point opening has a direct bearing on cam angle or dwell, which is the number of degrees that breaker cam rotates from the time points close until they open again. (Figure 4)

NOTE: Breaker arm rubbing block must be positioned at a high point on cam when adjusting point gap.

4. Adjust point gap or dwell (see following).
5. Make sure that all distributor wire terminals are clean and tight.
6. Install rotor and distributor cap.

NOTE: Use notch on outer edge of distributor cap as a guide for proper replacement (over primary wire) of cap. It is possible to install incorrectly.

7. Press all wires firmly into cap towers.

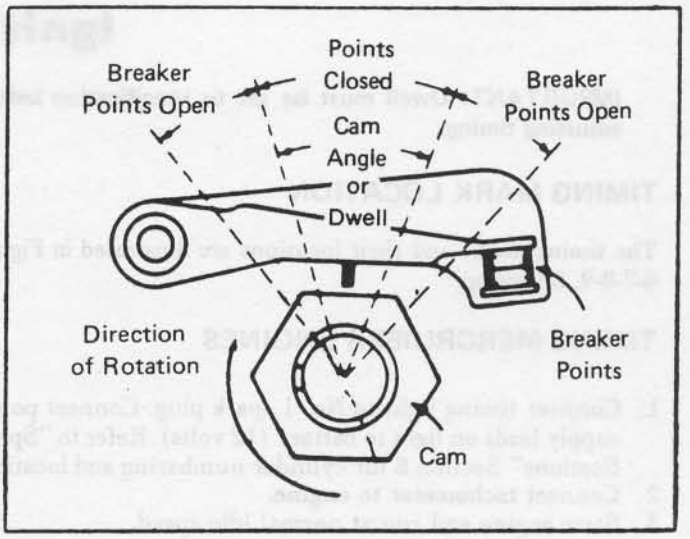


Figure 4. Cam Angle

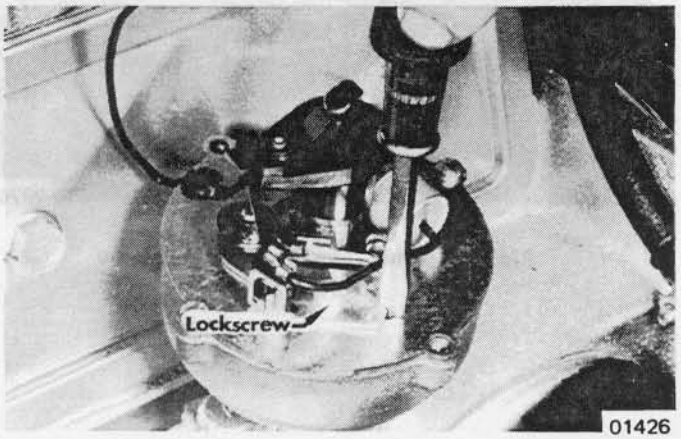
Point Gap and Dwell Adjustment

NOTE: Does not apply to Thunderbolt Ignition.

CAUTION: If dwell adjustment is changed, engine timing must be checked.

MERCRUISER STANDARD IGNITION

Point gap or dwell can be adjusted by 2 methods. It is preferred that points be adjusted with a feeler gauge, then checked (with a dwell meter) with engine running. Points, however, also can be adjusted, as well as checked, with a dwell meter:



DWELL METER

1. Remove distributor cap.
2. Remove rotor and connect dwell meter leads.
3. Loosen point lock screw slightly.
4. While cranking engine with starter, adjust dwell with a screwdriver (Figure 5) to obtain reading on dwell meter, as specified in "Specifications" Section 8, and tighten lock-screw. (Dwell reading will be unsteady using this method.)

NOTE: Cam angle increases as point opening is decreased and vice versa.

5. Install rotor and distributor cap and recheck dwell with engine running.

FEELER GAUGE

1. If necessary, align points by bending stationary bracket. DO NOT bend the breaker arm.
2. Rotate distributor until rubbing block rests on peak of cam lobe, which will provide maximum breaker point opening.
3. Insert correct feeler gauge between breaker points.
4. Loosen lockscrew and adjust points to correct gap.
5. After adjusting contact point opening to specifications, check cam angle or dwell with a dwell meter.

Figure 5. Adjusting Points (Typical View)

Ignition Timing

IMPORTANT: Dwell must be set to specification before adjusting timing.

TIMING MARK LOCATION

The timing marks and their locations are illustrated in Figures 6-7-8-9, following.

TIMING MERCRUISER ENGINES

1. Connect timing light to No. 1 spark plug. Connect power supply leads on light to battery (12 volts). Refer to "Specifications" Section 8 for cylinder numbering and location.
2. Connect tachometer to engine.
3. Start engine and run at normal idle speed.
4. Aim timing light at timing tab, located on timing gear cover and crankshaft harmonic balancer.

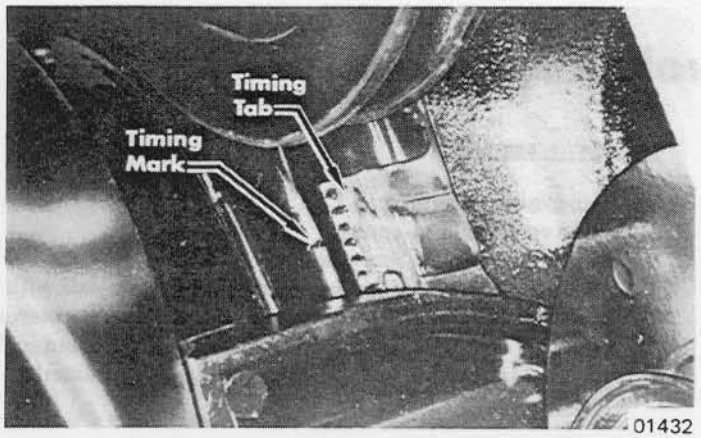


Figure 6. Timing Tab on "Chevrolet" 4 and 6-Cylinder Engines

Markings on tabs are in 2° increments, with greatest number of markings on "A" (Advance) side of "O" (Top Dead Center). All Before Top Dead Center (BTDC) settings fall on the "A" side of "O".

5. Adjust timing by loosening distributor clamp and rotating distributor body as required until timing mark on balancer or pulley lines up with mark on tab specified in "Specifications" Section 8. Tighten clamp and recheck location of timing mark.
6. Stop engine and remove timing light.

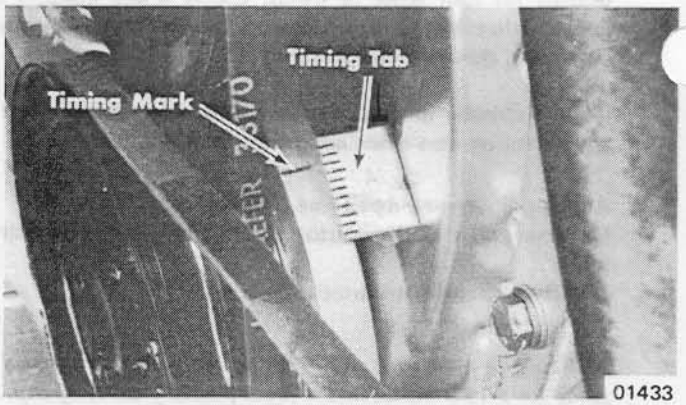


Figure 7. Timing Tab on "GM" V-8 Engine

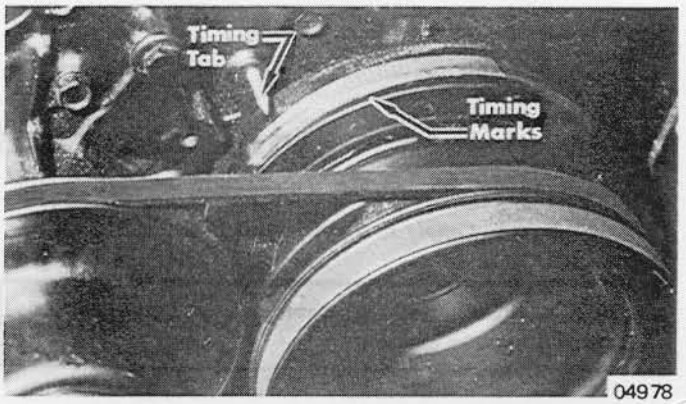


Figure 8. Timing Line on "Ford" V-8 Engines

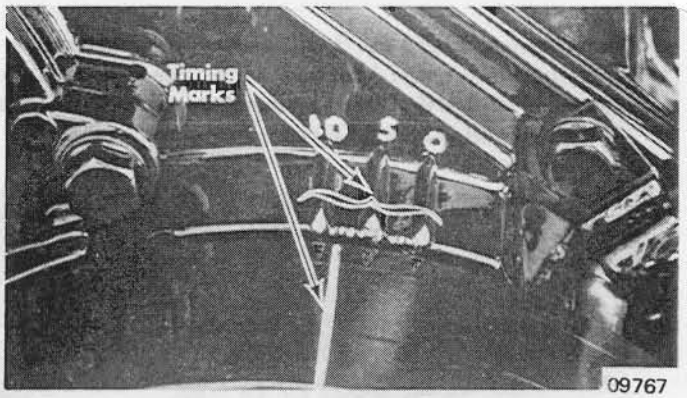


Figure 9. Timing Marks on "470" Engine

CARBURETOR ADJUSTMENT

The following carburetor adjustments should be performed.

1. Clean or replace carburetor inlet fuel filter.
2. Idle mixture and speed adjustment - all models
   a. Be sure that flame arrestor is installed.
   b. Start engine and allow to run until normal operating temperature is reached and choke is fully open.
   c. Stop engine; disconnect throttle cable from engine.
   d. Start engine: Adjust idle speed screw to obtain recommended idle RPM as indicated in "Specifications" Section 8.
   e. Adjust idle mixture screw(s).

   IMPORTANT: Do not turn idle mixture screw(s) tightly against stop, or mixture needle and/or seat will be damaged.

      1) Stop engine. Turn idle mixture adjusting needles in until they very lightly just touch adjusting needle seat, then back needles off seats the specified number of turns for preliminary idle adjustment.
      2) Start engine and run at idle RPM. Adjust idle mixture needle for highest, steadiest manifold vacuum reading. If a vacuum gauge is not available, obtain smoothest running, maximum idle speed by turning idle adjusting needle in until engine RPM begins to drop off, then backing needle off over "high spot" until engine RPM again drops off. Set idle adjusting needle halfway between the 2 points for satisfactory idle mixture setting. Repeat procedure with other needle. Should these adjustments show an increase in idle RPM, reset idle speed adjusting screw to obtain specified idle RPM and again adjust idle mixture adjusting needle. (Figures 1-thru-5)
   f. Shift unit into forward gear.
   g. Re-adjust idle speed screw to obtain recommended idle RPM.
3. Stop engine and install throttle cable, following. Check that throttle valves are fully open when remote control is in full forward position. On MerCruiser 120-thru-165, with throttle valves fully open, turn wide open throttle stop adjusting screw clockwise until screw just touches throttle lever. (Figure 1) Tighten set nut securely to prevent adjustment screw from turning. Return control to neutral gear, idle position, and check that idle stop screw is against stop.

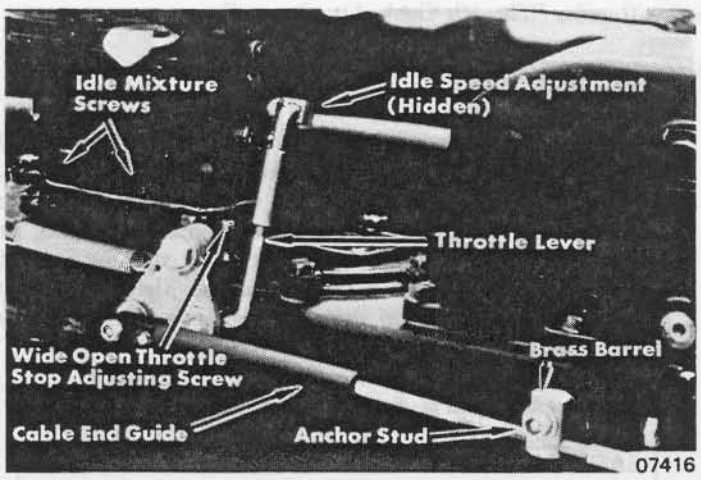


Figure 1. Idle Adjustment - MerCruiser 120-140-165

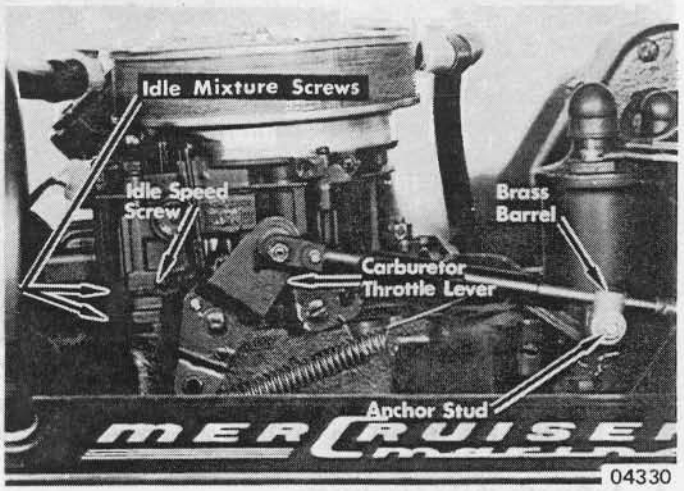


Figure 2. Idle and Mixture Screws Adjustment - MerCruiser 228, 250 (1977), 255 (Serial No. 4178300 and Above), 280, 350 and 400 Jet

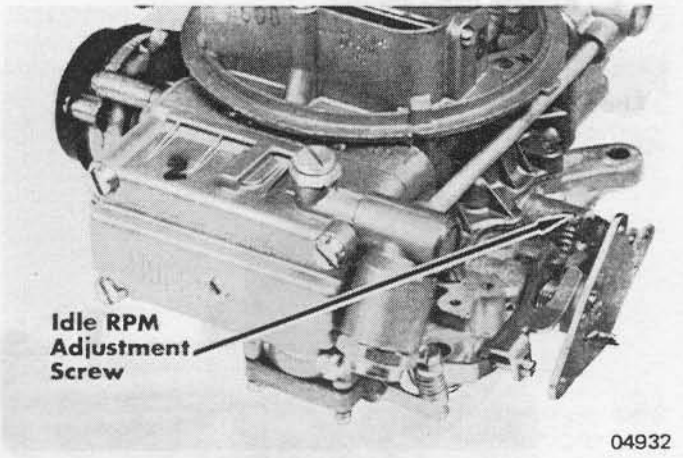


Figure 3. Idle Adjustment Screw - MerCruiser 888 (Serial No. 4166999 and Below), 225-S, 225 and 255 (Serial No. 4178299 and Below) (Typical)

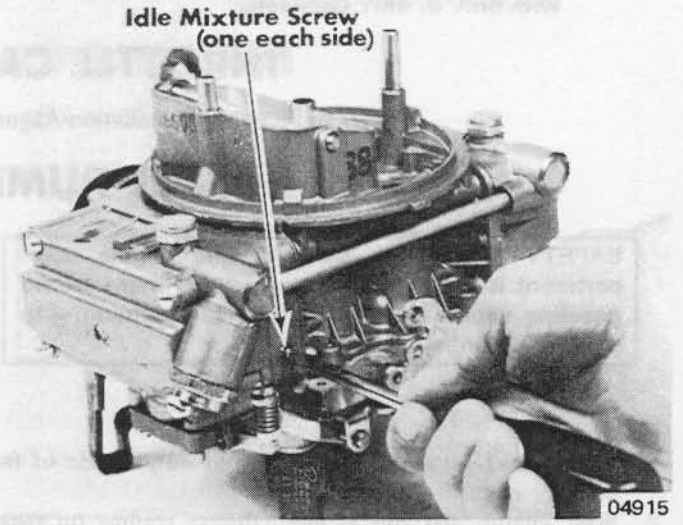


Figure 4. Idle Mixture Screw - MerCruiser 888 (Serial No. 4166999 and Below), 225-S, 225 and 255 (Serial No. 4178299 and Below) (Typical)

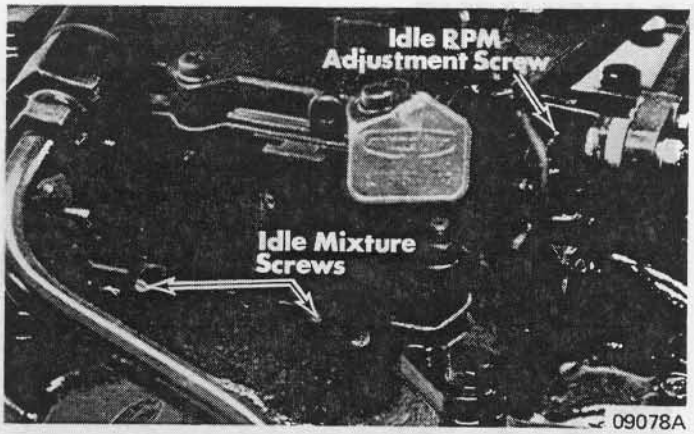


Figure 5. Idle and Mixture Screws Adjustment - MerCruiser 470, 888 (Serial No. 4167000 and Above), 898 and 233

4. Automatic choke adjustment:

ALL MODELS, except MODELS with 4MV or 4MY CARBURETOR

a. Remove flame arrestor.
b. Check choke valve for binding or sticking.

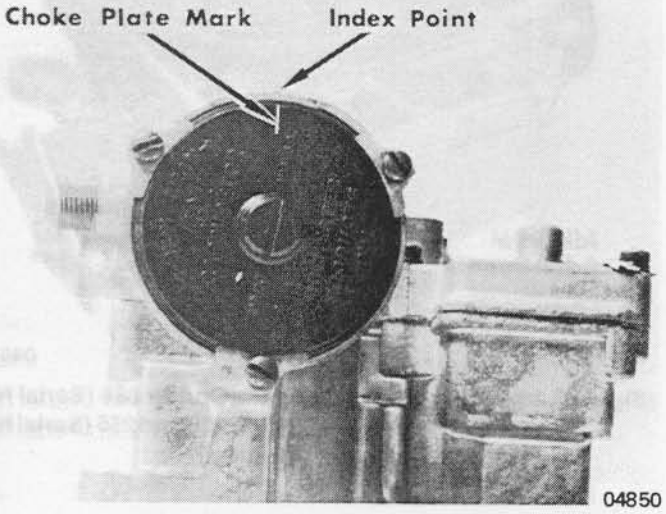


Figure 6. Typical Choke Setting - All Models except Models with 4MV or 4MY Carburetor

c. Loosen 3 retaining screws.
d. Rotate choke cover against coil tension until index mark is lined up with proper index point on housing. (Figure 6)
e. Before operation, choke should be lightly closed a room temperature.
f. At normal operating temperature, choke should move to full open.
g. After adjustment, tighten retaining screws and replace flame arrestor.

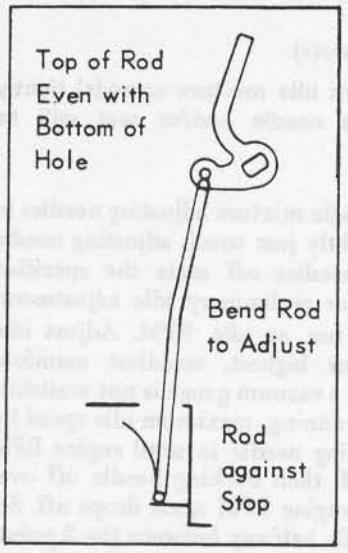


Figure 7. Choke Coil Rod Adjustment (Models with 4MV and 4MY Carburetors)

MERCRUISER MODELS with 4MV and 4MY CARBURETORS

a. Remove flame arrestor.
b. Disconnect choke coil rod from choke lever.
c. Hold choke valve shut in carburetor and position choke rod at bottom of choke lever hole.
d. Push choke coil rod DOWN to end of travel.
e. TOP of choke coil rod should be even with BOTTOM of hole in choke lever. (Figure 7)
f. Bend choke coil rod until proper position is reached.
g. Connect choke coil rod and replace flame arrestor.

THROTTLE CABLE ADJUSTMENTS

Refer to "Removal-Installation-Alignment" Section 2 under "Throttle Cable Attachment".

FUEL PUMP PRESSURE TEST

SAFETY WARNING: Be sure that engine compartment is well ventilated -- and that there are no gasoline vapors present during this operation -- to prevent potential fire hazard.

1. Attach fuel pump pressure gauge to output side of fuel pump.
2. Start engine and run at idle. Observe reading on gauge. Pressure should be as specified in "Specifications" Section 8 and remain constant at all speeds between idle and 1000 RPM.
3. If pressure is too low, inspect fuel lines for kinks, leaks and restrictions and correct any defects found. If necessary, remove fuel lines and blow out with compressed air to remove any foreign material. When reinstalling lines, be sure that they are not twisted or kinked, thereby causing restriction. If pressure is too low or too high or varies at different speeds, pump should be removed for repair or replacement.
4. Remove gauge and reconnect fuel line to fuel pump.
5. Inspect entire fuel system for leaks.

SAFETY WARNING: Make sure that fuel line connections are tight and that no fuel leaks exist.

BATTERY and BATTERY CABLES

SAFETY WARNING: Battery electrolyte is a corrosive acid and should be handled with care. If electrolyte is spilled or splashed on any part of the body, immediately flush the exposed area with liberal amounts of water and obtain medical aid as soon as possible. Safety glasses and rubber gloves are recommended when handling batteries or filling with electrolyte.

SAFETY WARNING: Hydrogen gases, that escape from the battery during charging, are explosive. Be sure that the battery compartment or area (where batteries are located) is well-vented and that bilge blower is in operation.

1. Inspect battery and cables and perform necessary service on these components.
2. Inspect for signs of corrosion on battery, cables and surrounding area, loose or broken carriers, cracked or bulged cases, dirt and acid, electrolyte leakage and low electrolyte level.
3. Fill cells to proper level with water.
4. Top of battery should be clean and battery fastened securely in position.
5. For best results, when cleaning batteries, wash first with a dilute ammonia or soda solution to neutralize any acid present, then flush off with clean water.
6. Keep vent plugs tight so that neutralizing solution does not enter cell.
7. Hold-down device should be kept tight enough to prevent battery from shaking around in its holder, but it should not be tightened to point where battery case will be placed under a severe strain.
8. To insure good contact, battery cables should be tight on battery posts. If battery posts or cable terminals are corroded, cables should be cleaned separately with a soda solution and wire brush. After cleaning and before installing clamps, apply a thin coating of Multipurpose Lubricant (C-92-63250) to posts and cable clamps to help retard corrosion.
9. If battery has remained under-charged, check for loose alternator drive belt, faulty alternator or voltage regulator.
10. If battery has been using too much water, voltage regulator setting may be too high, and regulator shold be replaced.

VALVE ADJUSTMENT

MERCRUISER ENGINES with "FORD" BLOCK

No adjustment required. See "Engine Mechanical" Section 5.

MERCRUISER ENGINES with "GM" BLOCK

NOTE: Following procedure, performed with engine running, should be completed ONLY if readjustment is required.

1. After engine has reached normal operating temperature, remove valve cover and install rocker stoppers (C-91-66273) on rocker arms to prevent oil from running out.
2. With engine running at idle, back off valve rocker arm nut until valve rocker arm starts to clatter.
3. Turn rocker arm nut down slowly until clatter just stops. This is zero lash position.
4. Turn nut down ¼ additional turn and pause until engine runs smoothly. Repeat additional ¼ turns, pausing each time, until nut has been turned down ¾-turn from zero lash position.

   NOTE: This ¾-turn preload adjustment must be done slowly to allow lifter to adjust itself to prevent possibility of interference between inlet valve head and top of piston, which might result in internal damage and/or bent push rods. Noisy lifters should be replaced.

5. Repeat Steps 2, 3 and 4, above, to adjust rest of valves.
6. Remove rocker stoppers and install valve cover(s) with new gasket(s).

MANIFOLD

1. Inspect manifold for air, fuel and water leaks.
2. Tighten all cap screws and nuts. A slight air leak in intake manifold can drastically reduce engine performance.

CRANKCASE VENTILATION

1. Remove hose(s) which runs from fitting on rocker arm cover to carburetor(s).
2. Clean hose(s) and fittings if necessary.
3. Clean flame arrestor.

SECTION I - GENERAL INFORMATION

mercruiser

PART C - LUBRICATION

MERCURY MARINE

A BRUNSWICK COMPANY

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MERCRUISER LUBRICANT and MAINTENANCE CHART

ENGINE

Locations	After 1st 20 Hrs. of Operation	Every 50 Hours of Operation	Every 100 Hours of Operation	Once Each Year
Alternator and Starter	None Required			
Alternator Rear Screen, Check				● +
Battery Electrolyte Level, Check	●	●		
Breaker Points, Inspect			●*	
Circulating Water Pump Bolts (Ford Engines), Check for Tightness	Every 6 Months or 500 Hours			
Cooling System Hoses and Connections, Check for Leaks and Wear	●		●	
Crankcase Ventilating System, Check and Clean			●	
Distributor Cam, Lubricate				6 + □
Drive Belts (All), Inspect for Wear and Tension	●	●		
Electrical Connections (All), Check	●			●
Flame Arrestor, Clean	●		●	
Fuel Filter (Water Separator), Replace				●
Fuel Filter Element (in Carburetor), Replace	● □			● □
Fuel System Lines and Connections, Check for Leaks and Wear	●	●		
Oil (Engine), Change	1		1	
Oil Filter, Change	●		●	
Oil Filler Cap (Vent-Type), Clean			●	
Parts, Check for Loose, Damaged or Missing		●		●
Power Steering Fluid Level, Check		2		
Spark Plugs, Inspect Condition				●*
Throttle and Shift Linkage Pivot Points, Inspect and Lubricate			1 +	1 +

DRIVE

Alignment (Engine and Drive), Check	● □			● □
Bellows and Clamps, Inspect	● +			● +
Drive Unit, Clean and Inspect Exterior			● +	● +
Engine Mount, Drive, Steering Cable and Trim Cylinder Fasteners, Check for Tightness	●		●	
Gimbal Bearing, Lubricate			4	4
Hinge Pins, Lubricate		8 + □		8 + □
Propeller, Check for Damage		●		●
Propeller Shaft Splines, Lubricate			5 § +	5 § +
Power Steering Control Valve, Lubricate	4 ⊕		4 ⊕	4 ⊕
Power Trim Pump Oil Level, Check	1		1	1
Steering Cable and Steering Lever, Lubricate	4 ⊕		4 ⊕	4 ⊕
Stern Drive Oil Level, Check	3	3		
Stern Drive Oil, Change			3	3
Swivel Pins (Upper and Lower), Lubricate	4 +		4 +	4 +
Transmission Fluid Level, Check	2	2		
Transmission Fluid, Change				2
Transmission Oil Strainer Screen, Clean				●
Transmission Oil Cooler Electrodes, Check	Every 6 Months			

(Continued on Next Page)

DRIVE (Cont.)

Locations	After 1st 20 Hrs. of Operation	Every 50 Hours of Operation	Every 100 Hours of Operation	Once Each Year
Transmission Output Housing Bearing, Lubricate			4 □	4 □
Trim Tab and Anodic Plate, Inspect		Every 30 Days +		
U-Joint Coupling Splines, Lubricate	● □			● □
U-Joint Cross Bearings, Lubricate			7 □	7 □
Water Pump (Drive Unit) and Impeller, Inspect				● □

1 - Use Formula 4 Quicksilver Oil (C-92-65187-24)
2 - Use Automatic Transmission Fluid (Type "A", Suffix "A")
3 - Use Quicksilver Super-Duty Lubricant (C-92-68617)
4 - Use Multipurpose Lubricant (C-92-63250)
5 - Use Perfect Seal (C-92-34227)
6 - Use suitable high-melting-point, non-bleeding grease
7 - Use Universal Joint Lubricant Kit (C-92-74057A1)
8 - Use Anti-Corrosion Grease (C-92-74048)

✱ *Does not apply to "Thunderbolt Ignition"*
□ *By an authorized MerCruiser dealer*
\+ *If unit is operated in salt water, requires more frequent attention*
⊕ *Every 60 days in fresh water, 30 days in salt water area*
§ *Lubricate during every installation*

NOTE: Complete list of maintenance is not applicable to all models. The charts, preceding, are based on average operating conditions. Under severe operating conditions, continuous heavy duty or high speed operation, the inspection and maintenance intervals should be shortened.

STERN DRIVE LUBRICANT CAPACITIES

Model	Capacity
MerCruiser I	32 Fl. Oz. (946ml)
MerCruiser II-TR	4 Qts.+* (3.78L)
MerCruiser II-TRS	81 Fl. Oz.+ (2.4L)

* *Approximately* + *Stern Drive Capacity Plus Reservoir*

NOTE: After filling a stern drive unit, that had been drained of all lubricant, the lubricant level must be rechecked after a "run-in" period of about one minute. This procedure assures that any air pockets, which may have developed during filling, will be eliminated. Additional lubricant may have to be added after rechecking to "top-off" the unit.

ENGINE LUBRICATION

Oil Selection

Crankcase oil should be selected to give the best performance under the climatic and operating conditions prevalent in the area in which the engine is operated. An oil, which will provide adequate lubrication under high operating temperatures, is required during warm or hot weather. An oil, which will permit easy starting at the lowest atmospheric temperature likely to be encountered, should be used during the colder months.

When crankcase is drained and refilled, crankcase oil should be selected, not on basis of existing temperature at time of change, but on lowest temperature anticipated for period during which oil is to be used.

We recommend Mercury Marine 4-Cycle Marine Motor Oil Formula 4R. If not available, use any good grade automotive oil of correct viscosity which has an A.P.I. classification of "SE".

The following chart shows the recommended viscosity for various temperature ranges and also the intervals at which the oil should be changed.

If the lowest anticipated temperature, during the interval in which the oil will remain in the crankcase, is	. . . the following Viscosity Oils and A.P.I. Classifications are recommended.	When to Change Crankcase Oil and Oil Filter		
		Prevailing Daytime Temperature	Initial Oil Change Interval	Regular Oil Change Interval
90°F (32°C)	SAE 40 "SE"	Above 90°F (32°C)	1st 60 days or 20 hours of operation, whichever occurs first	Every 100 hrs. of operation or 60 days, whichever occurs first.
32°F (0°C)	SAE 30 "SE"	Above 32°F (0°C)	1st 60 days or 20 hours of operation, whichever occurs first	Every 100 hrs. of operation or 60 days, whichever occurs first.
0°F (-18°C)	SAE 20W "SE"	Below 32°F (0°C) or during adverse operating conditions	First 30 days or 20 hours of operation, whichever occurs first	Every 100 hrs. of operation or 60 days, whichever occurs first.

Draining Engine Oil

1. Operate engine until normal temperature is indicated. If the crankcase is drained when the engine is cold, some of the suspended foreign material clings to the sides of the oil pan and will not drain out readily.
2. Remove dipstick and pump oil out of crankcase via dipstick tube.

   NOTE: An oil drain pump (C-91-34429) is available.

Filling Engine Crankcase

NOTE: For engine crankcase capacity, refer to "Specifications" Section 8.

Because of the effect the installed angle of engine has on oil level, the following procedure must be followed and boat must be at rest in water.

1. Pour oil into engine thru oil fill opening in rocker arm cover until level comes up to full mark on dipstick.
2. Start engine and run at idle speed for 5 minutes.
3. Stop engine and, after approximately 5 minutes, check level on dipstick.
4. Add quantity of oil required to bring level up to full mark.

Maintaining Oil Level

It must be emphasized that every internal combustion engine should use a certain amount of oil to act as a lubricating and cooling agent, particularly during the break-in period, and the initial rate of consumption gradually will decrease until it becomes stabilized after approximately 100 hours operation.

The engine oil level should be checked frequently and oil added when necessary.

When checking oil levels, the engine should be warm, the boat must be at rest in the water, the dipstick pushed down to the stop, and sufficient time (approximately 5 minutes) must be allowed for oil to drain back from the upper engine cavities to the pan, or a false reading may be obtained.

The space between the "Full" and "Add" marks represents one quart (946ml), and it is not necessary to add oil unless the level is at or below the "Add" mark.

Maintaining a proper oil level also is an important factor in controlling oil consumption. An over-full crankcase will allow oil to be splashed by the reciprocating parts onto the cylinder

walls in greater quantities than the rings can control. This excess oil, subsequently, will be drawn into the combustion chamber and burned.

On the other hand, when an engine is used principally at slow speed conditions, where considerable crankcase dilution occurs, a rapid lowering of the oil level may result when the boat is operated for some distance at high speed. This is due to the dilution from slow running which is removed from the crankcase by the heat of high speed operation. This is a normal condition and should not be mistaken for excessive oil consumption.

Oil Filter

A full-flow oil filter filters all of the oil delivered by the oil pump and, for this reason, interval of cartridge change is very important. Oil filter cartridge should be replaced after the first 20 hours and every 100 hours thereafter and at end of boating season.

IMPORTANT: The double filter, or "filter within a filter" (made for automotive use), SHOULD NOT be used on MerCruisers.

1. Remove filter from cylinder block.
2. Coat sealing ring on new filter with engine oil and thread filter on block. Hand-tighten securely.
3. Fill crankcase as outlined under "Filling Engine Crankcase" (preceding).
4. Check for oil leaks while engine is running.

Components

ALTERNATOR

Under normal operating conditions, alternator will not require lubrication.
Refer to "Electrical System" Section 3, Part C - "Alternator" for bearing replacement and lubrication.

STARTING MOTOR

Starting motor end frames are equipped with oil-less bearings which do not require lubricant.

DISTRIBUTOR LUBRICATION

Distributor cap should be removed every 100 hours.

Apply small amount of Delco-Remy Cam and Ball Bearing Lubricant or other suitable high-melting-point, non-bleeding grease on distributor cam surface.

STERN DRIVE LUBRICATION
Service

1. Clean entire unit thoroughly externally.
2. Inspect finish for damage or corrosion. Thoroughly clean damaged or corroded areas and apply primer and matching paint (Quicksilver Spray Paints).
3. Check entire unit for loose, damaged or missing parts. Tighten or replace as required.
4. Remove propeller and inspect. Trim nicks and burrs with a file, being careful not to remove more metal than absolutely necessary. Inspect for cracks, damaged or bent condition. If condition is doubtful, refer to an Authorized Quicksilver Propeller Repair Station in your area.
5. Check propeller shaft for bent condition. Shaft should be replaced if it is found to be bent.
6. Check lubricant level as outlined, following.
7. Coat propeller shaft splines with Perfect Seal (C-92-34227) and install propeller. (Figure 1 or 2)
8. Inspect universal joint bellows, shift cable bellows, water intake hose and exhaust tube for deterioration and damage. Service as required. Check all clamps for tightness.

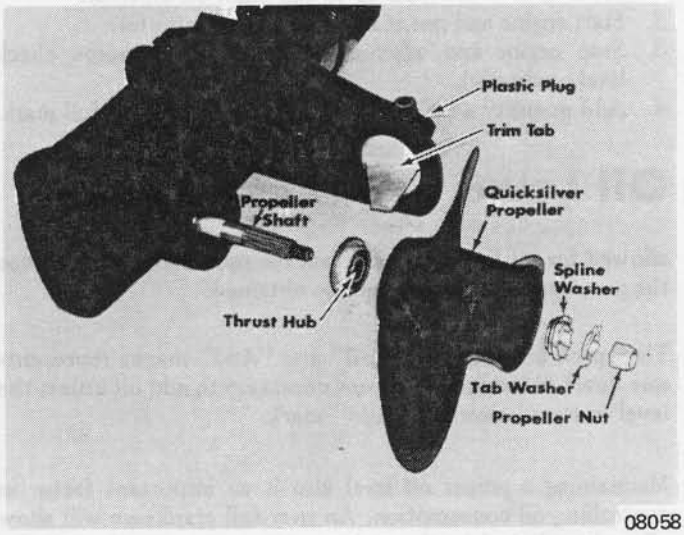


Figure 1. Propeller Shaft and Propeller Components, I-Drive

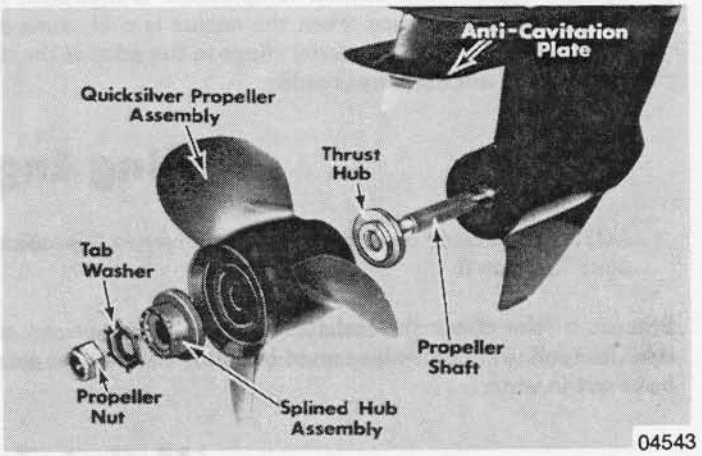


Figure 2. Propeller Shaft and Propeller Components, II-TR Drive

9. Check trim system for proper operation and connections.
10. Check and adjust engine alignment as outlined in Section 2.
11. Check and adjust shift cables as outlined in Section 2.
12. Lubricate all external lubrication points, as shown in Figure 3 and outlined under "Points of Lubrication", following.
13. Check and clean (if necessary) water intake opening. Replace inserts, if cracked or damaged.
14. Check and replace (if necessary) trim tab and anodic heads.

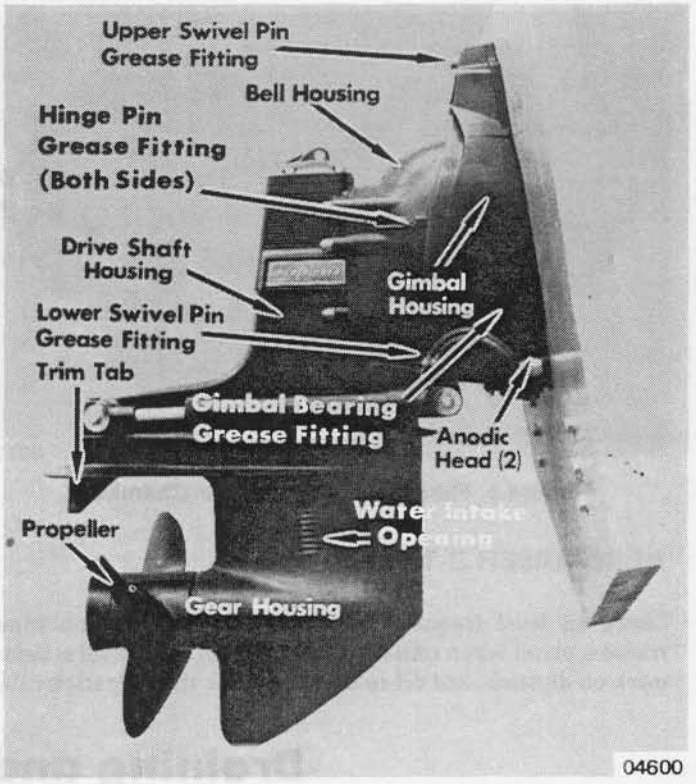


Figure 3. Stern Drive Unit Components - Right Side

Checking Lubricant Level

SAFETY WARNING: DO NOT remove vent or filler plug when drive is hot from operation. Expanded hot gear lubricant would be released thru plug hole. Check only when stern drive unit is cool.

CAUTION: DO NOT use regular automotive grease in stern drive unit.

CAUTION: If lubricant appears milky brown, or if large amounts of lubricant must be added to fill stern drive unit, it should be checked promptly to determine cause of problem.

Use only Quicksilver Super-Duty Gear Lubricant (C-92-68637-1, 120 lb. drum; C-92-68630-1, 37 lb. pail; C-92-68623-12, cans; C-92-68617-12, tubes) in all MerCruiser stern drive units. Lubricant should be changed once every 100 hours of operation or once each season.

MERCRUISER I-DRIVE

NOTE: Upper drive shaft housing gear chamber and lower unit gear chamber are connected.

1. Remove "Oil Vent" plug and gasket on side of drive shaft housing. (Figure 4) Lubricant must be even with bottom edge of threaded "Oil Vent" hole when unit is level.
2. Add Super-Duty Gear Lubricant, if level is down. Remove "Oil Fill" hole plug and gasket (located on lower side of gear housing). (Figure 5) Add lubricant thru "Fill" hole until oil appears at "Vent" hole in drive shaft housing.
3. Install "Oil Vent" and "Oil Fill" plugs with new seal gaskets.

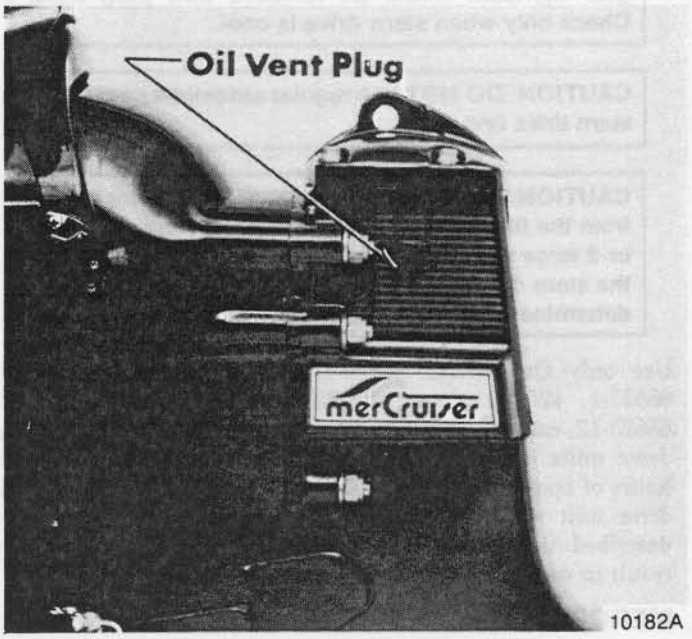


Figure 4. Drive Shaft Housing Oil Vent Plug

NOTE: Since the 2 oil chambers are inter-connected, the lower gear housing will automatically maintain a proper oil level, if the upper gear chamber oil level is maintained according to the previous instructions.

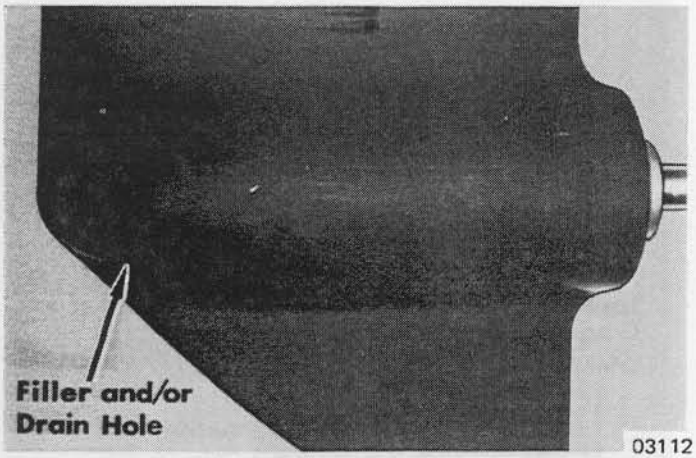


Figure 5. Fill Hole in Lower Gear Chamber

MERCRUISER II-TR and II-TRS

Check oil level frequently with dipstick (located on inner transom plate) when unit is cool. (Figure 6) If oil level is below mark on dipstick, add oil to dipstick mark thru dipstick tube.

CAUTION: Only a small amount of lubricant should be added thru reservoir dipstick tube. If reservoir is empty, drive unit MUST BE filled as shown in "Draining and Filling Drive Unit", following.

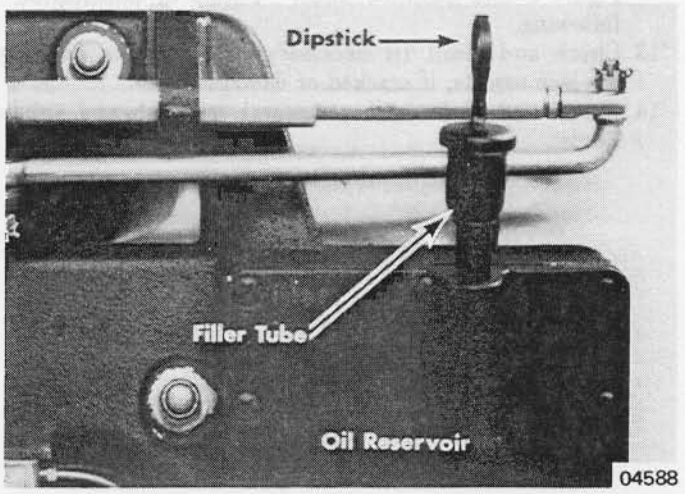


Figure 6. Checking Stern Drive Unit Oil Level

Draining and Filling Drive Unit

SAFETY WARNING: DO NOT remove vent or filler plug when drive is hot from operation. Expanded hot gear lubricant would be released thru plug hole. Check only when stern drive is cool.

CAUTION: DO NOT use regular automotive grease in stern drive unit.

CAUTION: If more than a teaspoonful of water drains from the filler hole, if lubricant appears milky brown, or if large amounts of lubricant must be added to fill the stern drive unit, it should be checked promptly to determine and correct problem.

Use only Quicksilver Super-Duty Gear Lubricant (C-92-68637-1, 120 lb. drum; C-92-68630-1, 37 lb. pail; C-92-68623-12, cans; C-92-68617-12, tubes) in all MerCruiser stern drive units. Lubricant should be changed once every 100 hours of operation or once each season. Do not attempt to fill drive unit with lubricant in any other manner than that described immediately following. Any other method may result in damage caused by lack of lubrication.

MERCRUISER I-DRIVE

NOTE: Upper drive shaft housing gear chamber and lower unit gear chamber are connected.

1. Drain stern drive unit by removing drain plug from lower end of gear housing on left side (Figure 1) and vent plug on upper gear chamber. (Figure 2)
2. To refill drive unit, insert lubricant tube into drain plug hole in lower unit (Figure 1) and inject lubricant until excess fluid starts to flow out of air vent hole in upper drive shaft housing. (Figure 2)
3. Install air vent and drain plugs, taking special care that washer is in place under head of each so water will not leak past threads into gear housing.

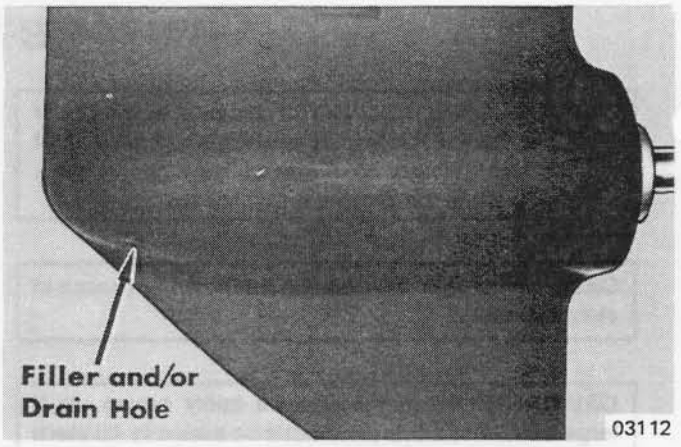


Figure 1. Drain Plug in Gear Housing

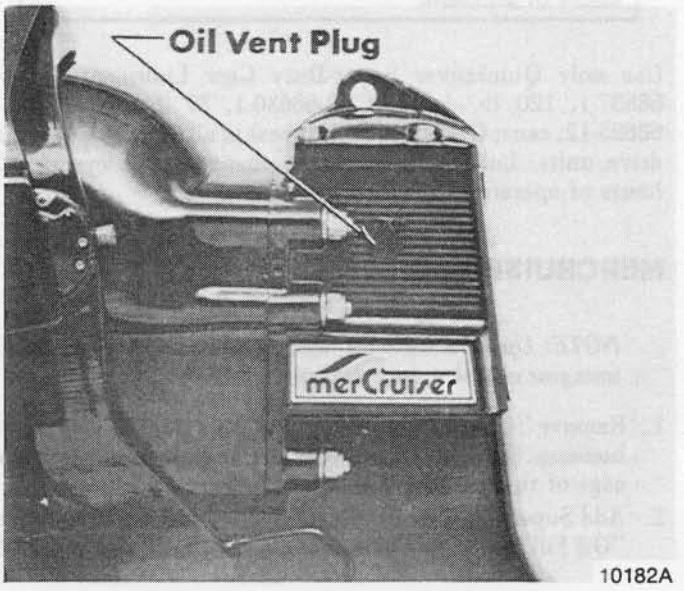


Figure 2. Oil Vent Plug in Upper Gear Chamber

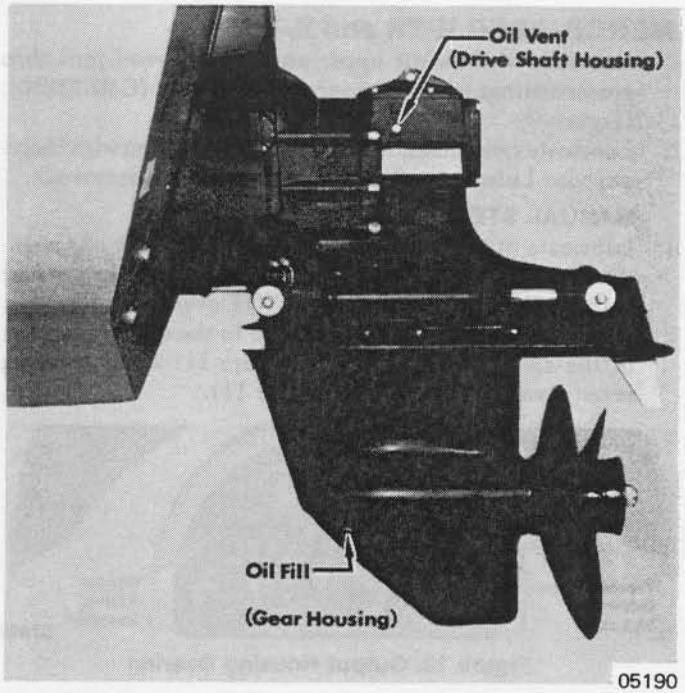


Figure 3. Oil Fill and "Oil Vent" Plugs

MERCRUISER II-TR and II-TRS

NOTE: To drain drive unit completely, drive must be installed in bell housing. (Figure 3)

1. Remove oil fill and "Oil Vent" plugs (Figure 3) and allow oil to drain completely.
2. To fill drive unit, install drive shaft housing "Oil Vent" plug. Drive unit must be filled with a hand-type lubricant pump thru gear housing oil fill hole. Unit must be filled until lubricant level meets line on dipstick (Figure 4) (located on inner transom plate reservoir).
3. After filling, thread oil fill plug (with new gasket under head) into gear housing and tighten securely.

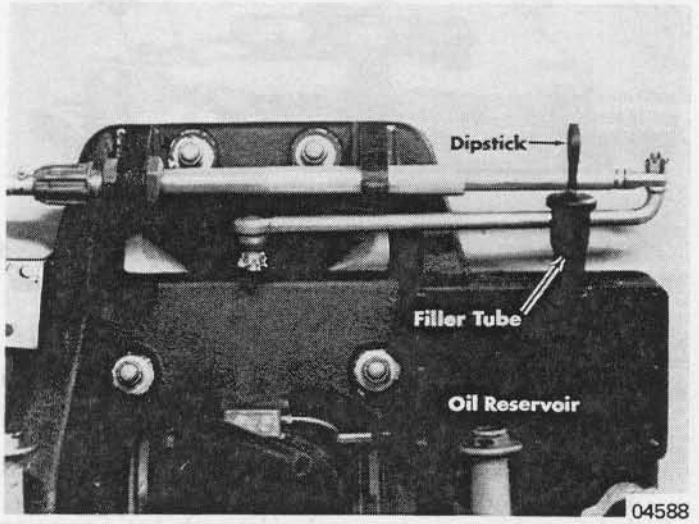


Figure 4. Dipstick - II-TR and II-TRS

Points of Lubrication

MERCRUISER I-DRIVE

Every 50 hours of operation, or at least once a season, lubricate the various Stern Drive components with Quicksilver Multipurpose Lubricant (C-92-63250) and thru grease fittings.

1. Inside boat:

WITHOUT Power Steering

a. Ride-Guide steering cable end next to hand nut. ("A" in Figure 5) DO NOT over-lubricate cable.
b. Socket of pivot of steering arm. ("B" in Figure 5)
c. Exposed shaft of cable traversing thru cable guide tube. ("C" in Figure 5)
d. Steering link rod to steering cable "D".

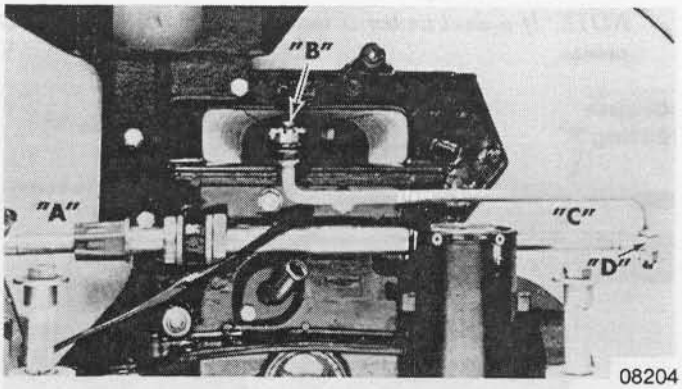


Figure 5. Points of Lubrication, Inside Boat - WITHOUT Power Steering

WITH Power Steering - In-Line Engines

a. Lubricate control valve thru grease fitting "A" with Multipurpose Lubricant until grease appears around rubber boot. (Figure 6)
b. Coat Power Steering extension rod "B" and exposed steering cable end "C" with Multipurpose. (Figure 6)
c. Lubricate cable end guide (Figure 6) pivot point "D" with SAE 30W engine oil.
d. Check Power Steering fluid level and add type "A" automatic transmission fluid as required. Refer to "Filling System with Fluid", preceding.

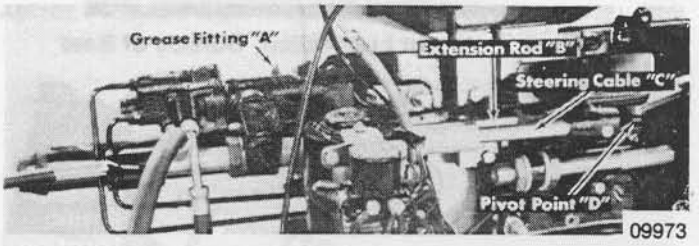


Figure 6. Points of Lubrication, Inside of Boat - WITH Power Steering (In-Line Engines)

WITH Power Steering - V-8 Engines

a. Lubricate Ride-Guide Steering cable through grease fitting ("A" in Figure 7) on transom end of cable with Multipurpose Lubricant only when cable is fully retracted. If cable is lubricated while extended, hydraulic lock could occur.

NOTE: Ride-Guide Steering cable is lubricated at the factory and requires no additional lubrication at initial installation.

b. Lubricate pivot points "B" with Formula 4 Quicksilver Oil. Lubricate exposed portion of steering cable "C" and Power Steering output shaft "D" (when both are fully extended) and Power Steering control valve "E" with Multipurpose.
c. Check all connections for loose fasteners and/or wear while performing lubrication.

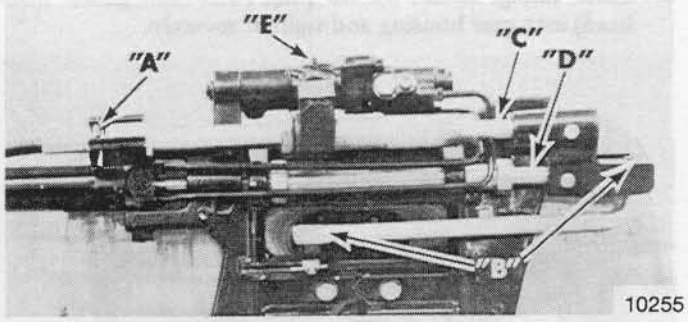


Figure 7. Lubrication Points Inside of Boat - WITH Power Steering (V-8 Engines)

2. Outside of boat:
   a. Gimbal housing upper and lower swivel pins. ("A" and "D" in Figure 8)
   b. Gimbal bearing. ("C" in Figure 8)
3. Lubricate universal joint bearings with Universal Joint Lubricant Kit (C-92-74057A1).
4. Lubricate hinge pin (one each side) with Anti-Corrosion Grease (C-92-74048). ("B" in Figure 8)

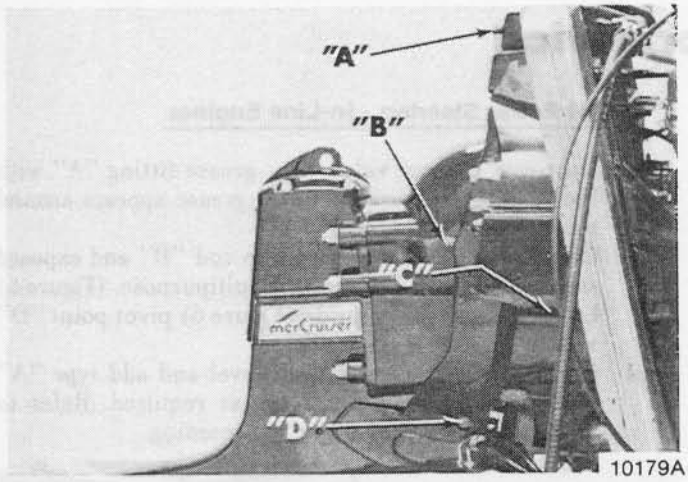


Figure 8. Points of Lubrication, Outside of Boat

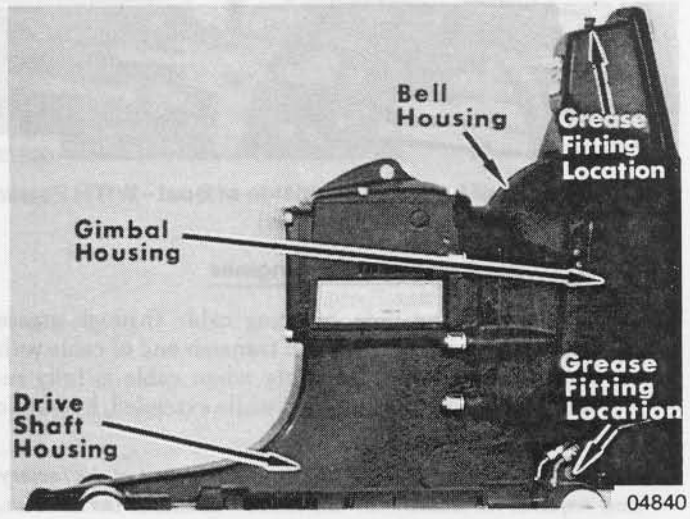


Figure 9. Points of Lubrication - II-TR and II-TRS

MERCRUISER II-TR and II-TRS

1. Lubricate drive unit upper and lower swivel pins thru grease fittings with Multipurpose Lubricant (C-92-63250). (Figure 9)
2. Lubricate transmission output housing bearing with Multipurpose Lubricant. (Figure 10, Drive Unit Removed)

MANUAL STEERING

1. Lubricate steering cable with a small amount of Quicksilver Multipurpose Lubricant (C-92-63250) thru grease fitting. ("A" in Figure 11) DO NOT over-lubricate cable.
2. Apply a light coat of Multipurpose to the exposed portion of the steering cable ("B" in Figure 11) and to steering lever pivot points ("C" in Figure 11).

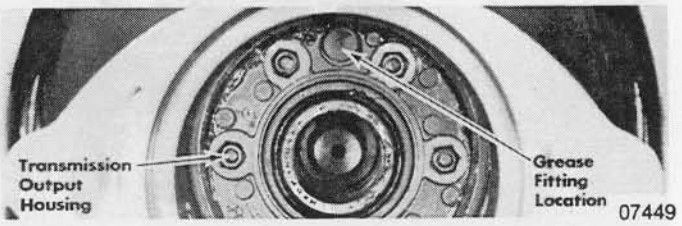


Figure 10. Output Housing Bearing

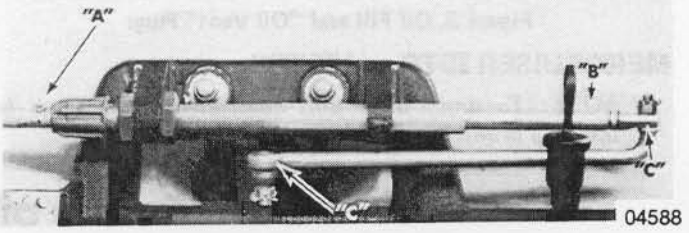


Figure 11. Steering Cable Lubrication Points - Manual Steering

POWER STEERING

1. Lubricate steering cable with a small amount of Quicksilver Multipurpose Lubricant (C-92-63250) thru grease fitting ("A" in Figure 12) ONLY when cable is fully retracted. If cable is lubricated while extended, hydraulic lock could occur.
2. Apply a light coat of grease to the exposed portion of the Power Steering cable ("B" in Figure 12) and to extension rod ("D" in Figure 12). DO NOT over-lubricate cable.
3. Lubricate Power Steering valve with Quicksilver Multipurpose Lubricant (C-92-63250) thru grease fitting ("E" in Figure 12) until a small amount of grease comes out from under rubber boot on valve.
4. Lubricate steering lever pivot points ("C" in Figure 12) with Formula 4 Quicksilver Oil.

   NOTE: If a dual tie bar is installed, also lubricate its pivot points.

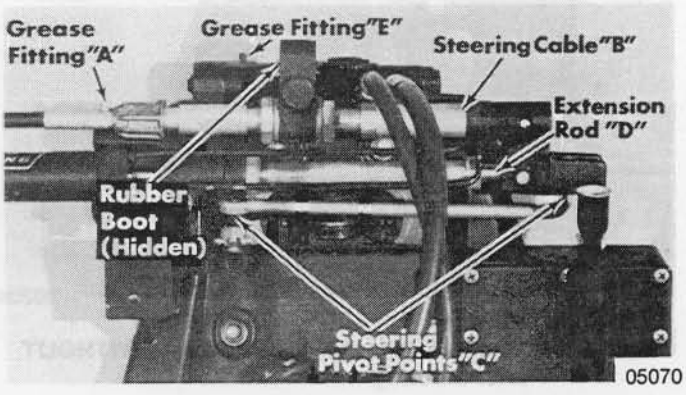
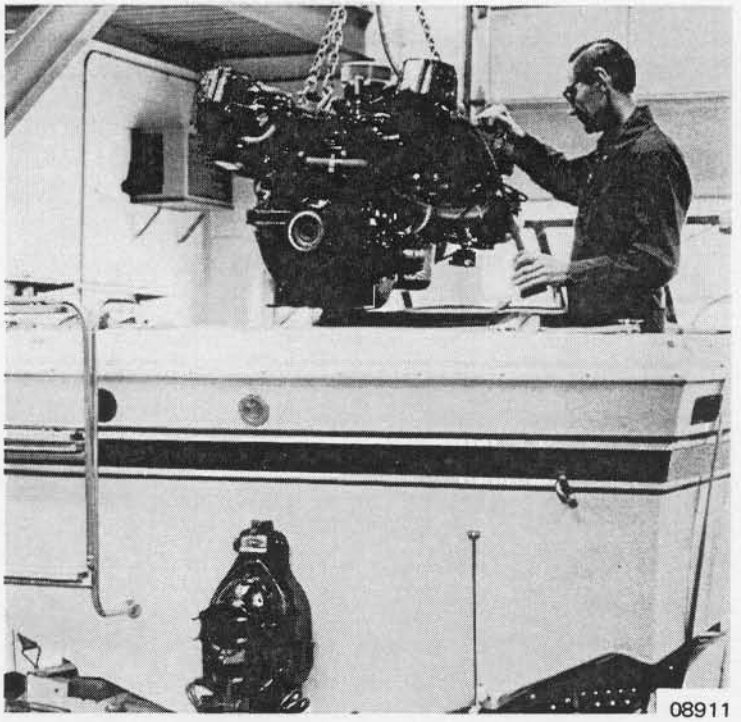


Figure 12. Steering Cable Lubrication Points - Power Steering

REMOVAL, INSTALLATION, ALIGNMENT

MERCRUISER Section 2



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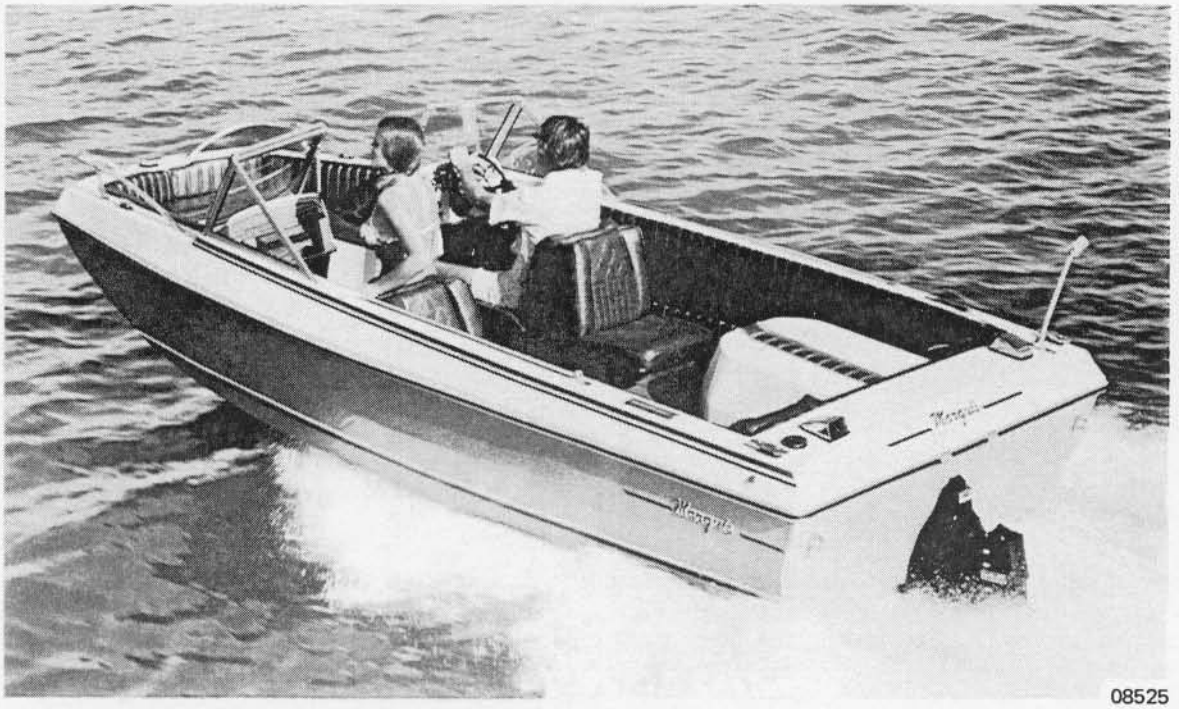
SECTION 2 - REMOVAL, INSTALLATION and ALIGNMENT

PART A - MERCRUISER 120-140-165-470



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MERCURY MARINE

A BRUNSWICK COMPANY

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MERCRUISER 120-140-165 and 470 ENGINE

REMOVAL

NOTE: Stern drive unit must be removed prior to engine removal. Refer to "Stern Drive Removal" (see "Index").

1. Disconnect battery cables from battery and remove instrument panel harness connector plug from engine harness receptacle.
2. Disconnect fuel line and throttle cable.
3. Disconnect brown and black shift cut-out switch wires from terminal block (located on shift plate).
4. Remove red and black Power Trim pump motor wires from engine.
5. Disconnect water inlet hose and exhaust elbow bellows.
6. Remove drive unit shift cable from "J" clamp (located on flywheel housing).
7. Disconnect vacuum hose from intake manifold (if applicable).
8. Disconnect any accessories that are connected to the engine.
9. Support engine with suitable sling thru lifting eyes on engine and remove front and rear engine mounting bolts.
10. Carefully remove engine.

INSTALLATION and ALIGNMENT

IMPORTANT: It is necessary that transom plates and Ride-Guide Steering be installed BEFORE PROCEEDING with "Engine Installation". Refer to "Stern Drive Installation" (see "Index").

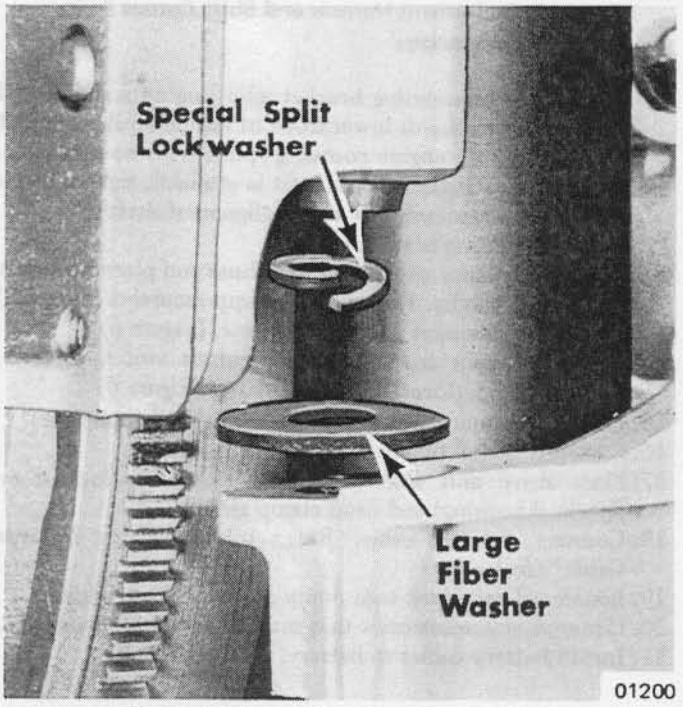


Figure 1. Engine Mounting Bracket Parts

1. Lift engine with an overhead hoist, using suitable sling and lifting eyes on engine.
2. Lubricate engine coupling splines with Universal Joint Lubricant (C-92-74058).
3. Install front engine mounting bracket.
4. Place large fiber washer on top of inner transom plate engine mounting brackets and special split lockwasher inside fiber washer. (Figure 1)
5. Place engine over transom plate mounting brackets. Place hose clamps over rubber exhaust elbow bellows and position bellows over exhaust manifold outlet. Tighten hose clamps securely. (Figure 2)
6. Place steel washers and spacers on mounting bolts and insert bolts down thru rear engine mounts, (Figure 2) washers and mounting brackets. Thread elastic stop nuts on bolts. Torque to specification.

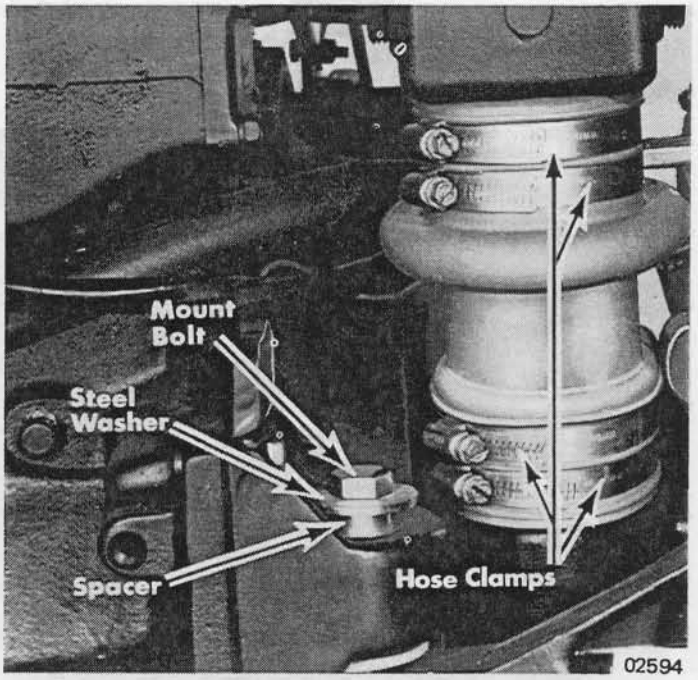


Figure 2. Exhaust Tube Installed

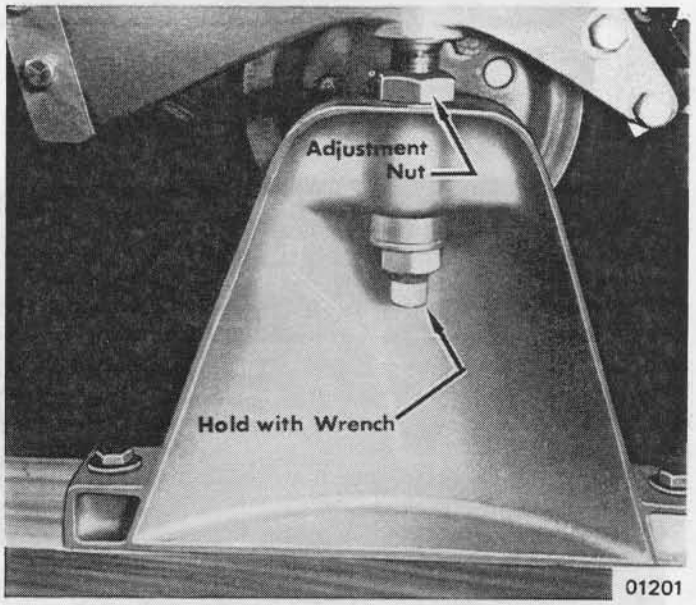


Figure 3. Installing Front Engine Mounting Bracket

7. Adjust front mounting bracket by turning adjusting nuts until bracket rests firmly on mount location in boat to relieve hoist tension. (Figure 3) Fasten mount to boat.
8. Insert small diameter end of Alignment Shaft (C-91-48247) or end of Alignment Tool (C-91-57797A3) shaft, which does not have threaded hole, thru gimbal bearing. (Figure 4) Move gimbal bearing with shaft, as required, to insert shaft into engine coupling spline. If shaft enters coupling freely with no pressure, alignment is correct. If not, proceed as in the following paragraph.

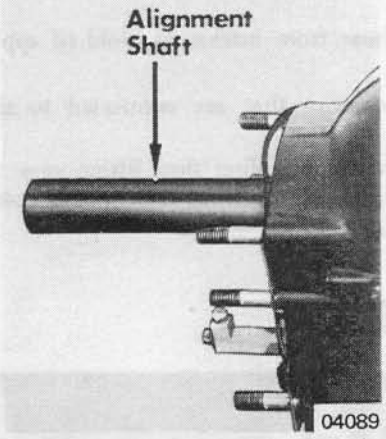


Figure 4. Alignment Shaft in Position

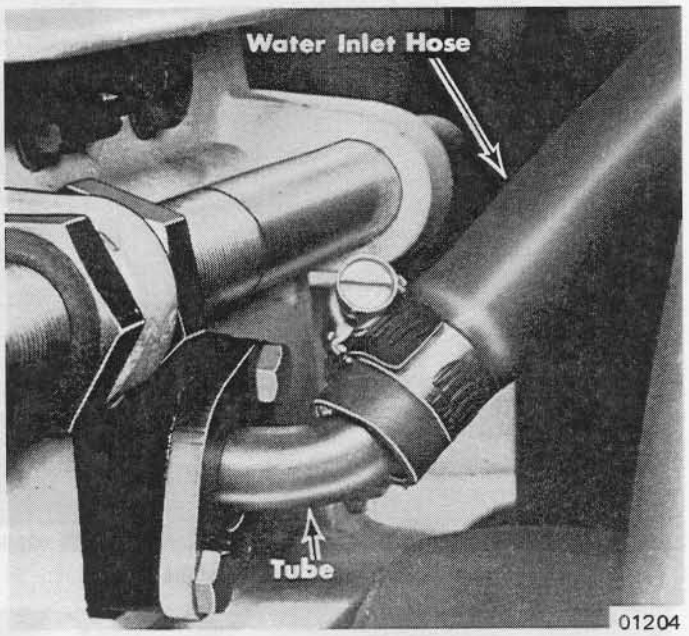


Figure 5. Installing Water Inlet Hose

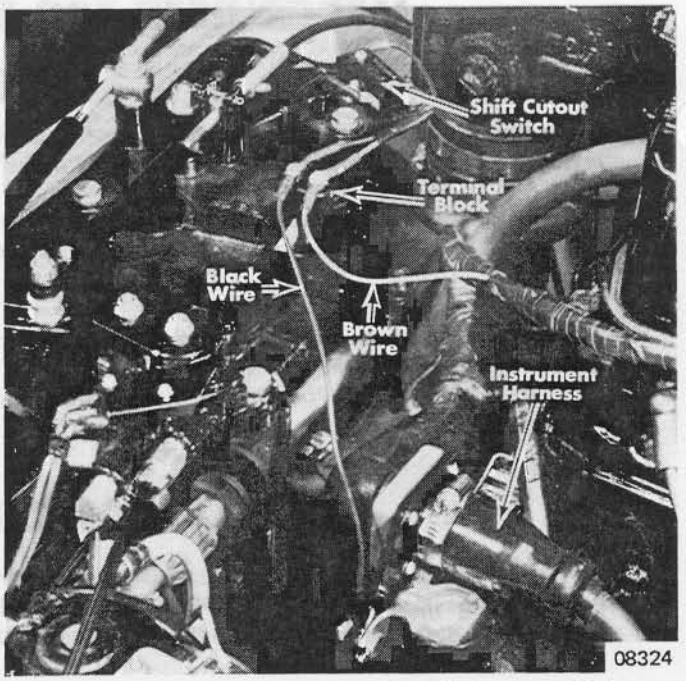
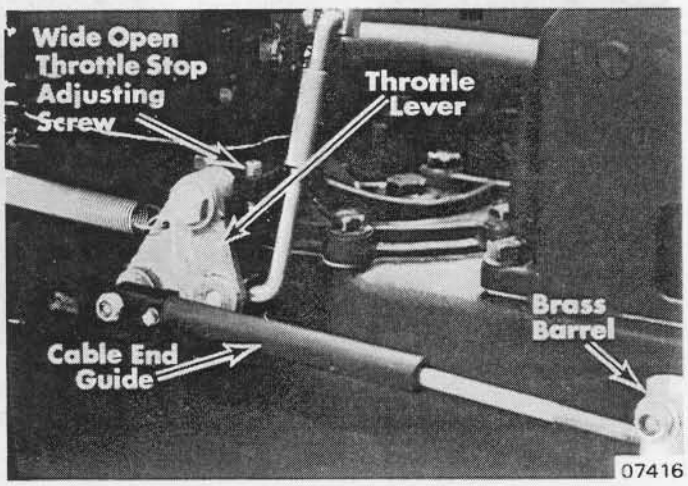


Figure 6. Instrument Harness and Shift Cutout Switch Connection

9. Loosen front mounting bracket adjusting nuts and thread either way to raise or lower front of engine until alignment shaft slides into engine coupling spline with no resistance.
10. After correct alignment shaft fit is attained, tighten lower adjusting nut securely. Re-check alignment shaft fit.
11. Secure mounting bracket to boat.
12. Place hose clamp over water inlet hose and place hose over copper inlet tube. Fasten hose clamp securely. (Figure 5)
13. Connect instrument harness to engine. (Figure 6)
14. Connect brown and black shift cutout switch wires to terminal block (located on shift plate). (Figure 6)
15. Connect vacuum hose to intake manifold (if applicable).
16. Carefully install fuel line. Check for fuel leaks.
17. Place drive unit shift cable in "J" clamp (located on flywheel housing) and bend clamp closed.
18. Connect throttle cable. Refer to "Attaching Throttle Cable" (following).
19. Install red and black trim pump motor wires to engine.
20. Connect any accessories that may have been disconnected.
21. Install battery cables to battery.

ATTACHING THROTTLE CABLE



1. Place remote control in neutral gear, idle position.
2. Fasten cable end guide to throttle lever with flat washer and nut. (Figure 7)
3. Grasp throttle cable behind brass barrel and push cable toward throttle lever. Adjust barrel to align with anchor stud. Fasten barrel to stud with flat washer and nut. (Figure 7)
4. Check that throttle valves are fully open when remote control is in full forward position. With throttle valves fully open, turn wide open throttle stop adjusting screw clockwise until screw just touches throttle lever. (Figure 7) Tighten set nut securely to prevent adjustment screw from turning. Return control to neutral gear, idle position, and check that idle stop screw is against stop.

Figure 7. Typical Throttle Control Cable Attachment

MERCRUISER 120-140-165 and 470 STERN DRIVE UNIT

REMOVAL

1. Shift drive unit into full forward.
2. Disconnect rear end of trim cylinders from drive unit.
3. Support drive unit with suitable sling thru lifting eye on top cover and remove 6 nuts which hold drive unit to bell housing. Carefully remove drive unit.
4. Remove/discard drive shaft housing to bell housing gasket.

INSTALLATION

CAUTION: Check engine alignment with Engine Coupler Alignment Shaft (C-91-48247 or C-91-57797A3) before installing stern drive unit. (Refer to "Engine Installation and Alignment" [use "Index"].)

1. Lubricate shifting slide assembly (Figure 1) with Multipurpose Lubricant (C-92-63250).

   NOTE: Slide assembly is free to rotate on core wire, so be sure that slide is located in the upright position during installation. Also be sure that bell housing rubber gasket and "O" ring are properly seated.

CAUTION: Be sure that rubber gasket is in place, or water will leak into bellows. (Figure 1)

2. Lubricate drive shaft housing pilot (Figure 2) with Multipurpose Lubricant, and U-joint shaft splines with Universal Joint Lubricant (C-92-74058).

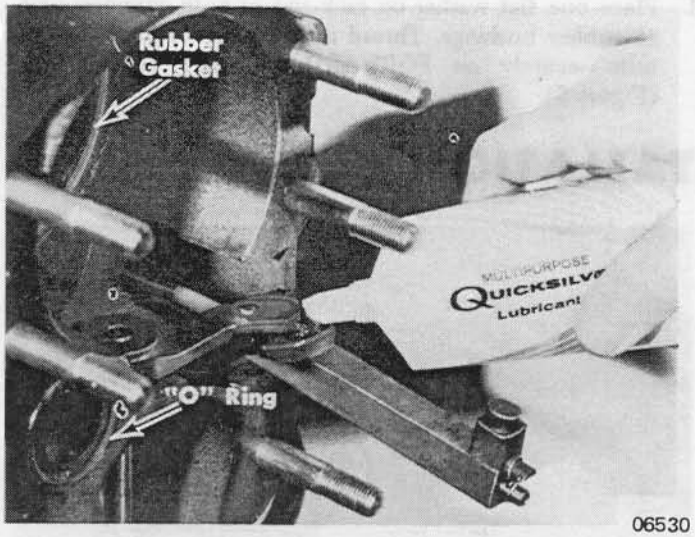


Figure 1. Lubricating Shifting Slide Assembly

CAUTION: If locating slot of shift lever in bell housing and coupler of intermediate shift shaft in drive shaft housing are not aligned as described in Steps 5 and 6, bell housing and shift shaft couplers will be damaged when drive unit is installed.

3. Align locating slot of shift lever coupler in bell housing straight to rear by moving shift lever to the right (facing transom from inside boat) and lubricate slot with Perfect Seal (C-92-34227).
4. Align coupler of intermediate shift shaft in drive shaft housing for straight entry into locating slot of shift lever in bell housing. Drive unit must be in forward gear position. Lubricate coupler surface with Perfect Seal.

   NOTE: It may be necessary to rotate propeller shaft to align intermediate shift shaft coupling with upper shift shaft slot.

   NOTE: Since the fit between the universal joint "O" rings and gimbal housing ball bearing is tight, it is recommended that a coating of Multipurpose Lubricant be placed on the two "O" rings. This will facilitate installation of the universal joint into the gimbal housing ball bearing.
5. Place drive shaft housing gasket on bell housing. (Figure 2)
6. Insert stern drive unit into bell housing bore as follows (Figure 2):
   a. Guide universal joint shaft thru bearing in gimbal housing and into drive coupling on engine. Also guide shift slide into opening in drive shaft housing.
   b. Be careful not to move shift slide assembly, or shift shaft coupler will not align.

   If universal joint shaft splines do not align with engine

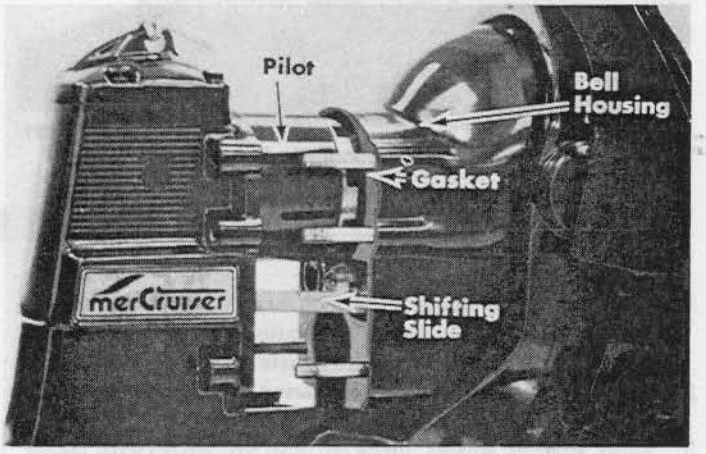


Figure 2. Inserting Unit into Bell Bore

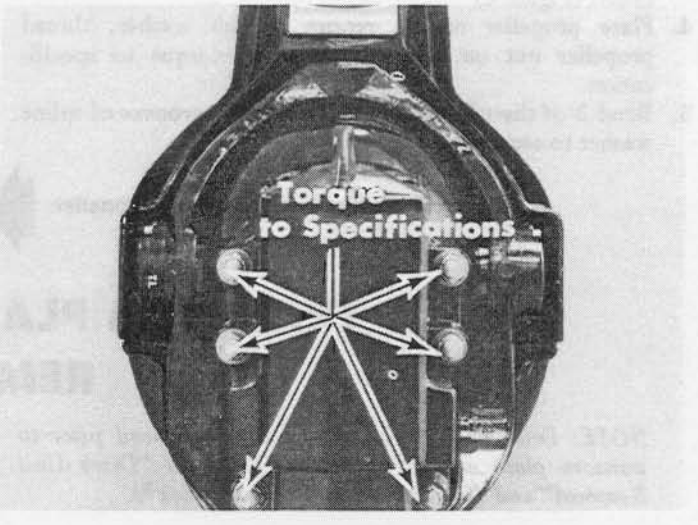


Figure 3. Fastening Drive Shaft Housing to Bell

coupling splines, rotate propeller shaft counterclockwise until drive unit can be pushed into position. Propeller should be placed on shaft for easier rotation. DO NOT rotate propeller shaft clockwise, or drive unit shift shaft will turn out of position.

7. Fasten drive shaft housing to bell housing studs with 6 flat washers and elastic stop nuts. Tighten evenly to specification. (Figure 3)

TRIM CYLINDERS INSTALLATION

IMPORTANT: On cylinders with aluminum rod aft ends (WITHOUT nylon coating), be sure that one small spiral grounding spring is installed between rubber bushings on each side of both forward and aft anchor pins on painted aluminum trim cylinder ends. (Figure 4) They are necessary to ground the trim cylinders to the stern drive unit in order to reduce galvanic corrosion. Trim cylinders with steel nylon coated aft end do not have spiral grounding spring on aft end.

NOTE: Forward anchor pin is installed previously. Refer to "Transom Plate Installation" (use "Index").

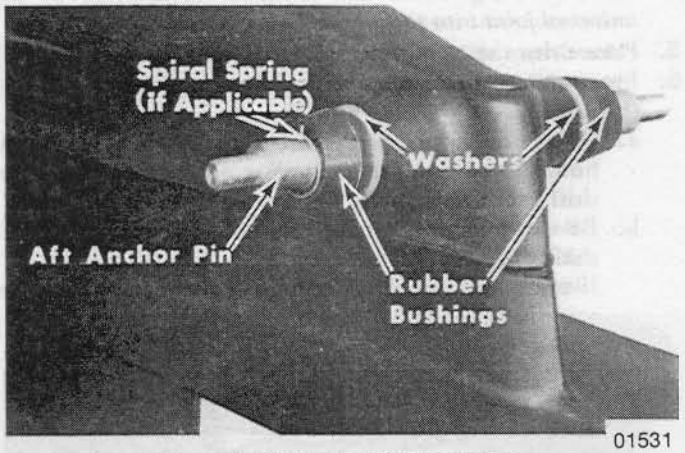


Figure 4. Aft Anchor Pin Installed

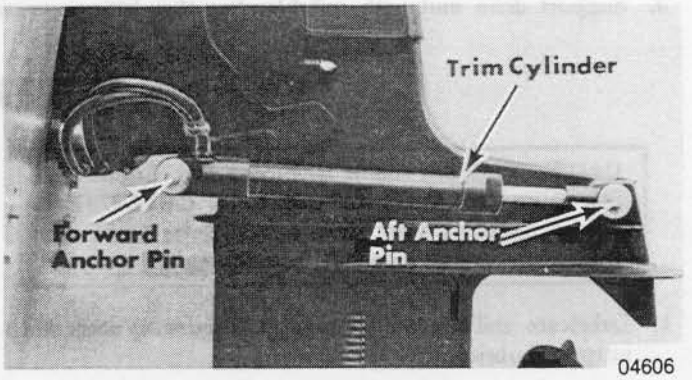


Figure 5. Power Trim Cylinder Installed

1. Insert aft anchor pin thru hole in drive shaft housing and place one large washer, one rubber bushing and one spiral spring (if applicable) on aft anchor pin on each side of drive shaft housing. (Figure 4)
2. Loosen nuts, which retain hydraulic cylinders to forward anchor pin, and place cylinders in position on aft anchor pin.
3. Place one rubber bushing in aft end mounting of each cylinder. Small diameter end of bushings face drive shaft housing.
4. Place one flat washer on each end of both cylinders next to rubber bushings. Thread nuts on anchor pins. Tighten nuts securely on FORWARD and AFT anchor pins. (Figure 5)

PROPELLER INSTALLATION

1. Apply a liberal coat of Perfect Seal (C-92-34227-1) on splines of propeller shaft, especially if operated in salt water, to aid in removing at any future time.
2. Place thrust hub and washer assembly into propeller hub (shoulder into recess of propeller).
3. While aligning splines, place jet-prop propeller (with thrust hub assembly) and spline washer on propeller shaft in this order. (Figure 6)
4. Place propeller nut in groove of tab washer, thread propeller nut on propeller shaft and torque to specification.
5. Bend 3 of the tabs of tab washer down in grooves of spline washer to secure propeller nut.

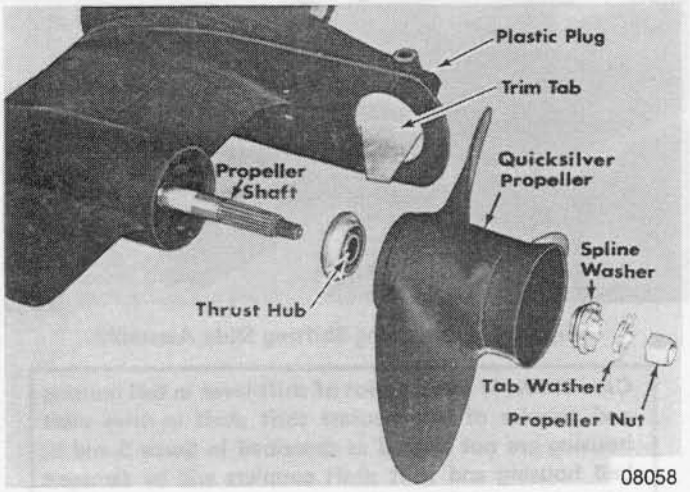


Figure 6. Installing and Removing Propeller

TRANSOM PLATE ASSEMBLY REMOVAL

NOTE: Drive unit and engine must be removed prior to transom plate assembly removal. Refer to "Drive Unit Removal" and "Engine Removal" (use "Index").

1. Remove steering link rod. (Figure 1)
2. Disconnect and remove steering cable from tube. (Figure 1)
3. Remove shift cables (drive unit and remote control) from shift plate.

4. Remove gray hydraulic hose from reverse lock valve and black hydraulic hose from trim pump. Cap hoses with cap (C-36172) and plug hose connections with plug (C-22-38609).
5. Remove and cap black plastic hydraulic hoses from trim sender. Plug hose connections.
6. Remove hose clamp that holds hydraulic hoses to inner transom plate.
7. Remove exhaust elbow.
8. Disconnect Power Trim panel wiring harness from pump, tilt limit switch from trim wiring harness and reverse lock valve cutout switch (if applicable) from pump, if pump is mounted separately. (Figure 1)
9. Remove screws and nuts which hold inner and outer transom plates together, then remove inner transom plate and outer transom plate in that order.

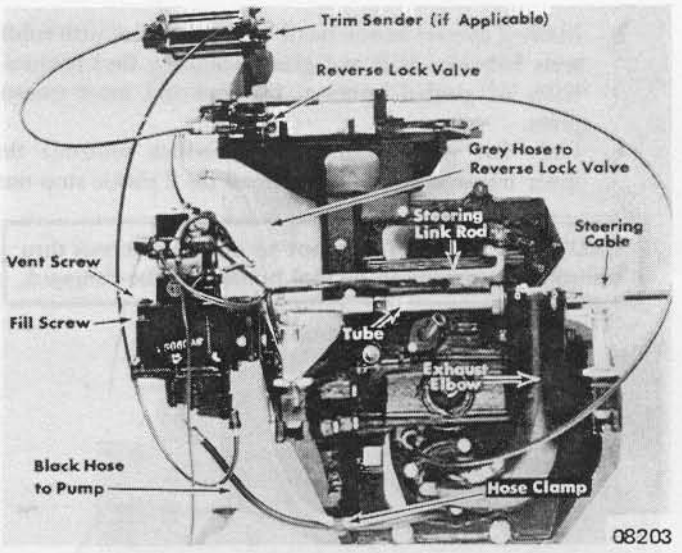


Figure 1. Transom Plate Removal

INSTALLATION

1. If hydraulic trim cylinders are not installed, install them per instructions following to prevent damage to cylinders and/or hoses.
   a. Insert forward anchor pin in gimbal ring.
   b. Place one flat washer, one rubber bushing and one spiral spring on each end of forward anchor pin.
   c. Place cylinders in position on forward anchor pin.
   d. Place one rubber bushing, one flat washer and one nut on each end of forward anchor pin. Tighten nuts securely.
2. Set gimbal housing assembly and inner transom plate in position over openings in transom as follows:
   a. Insert shift cable, trim limit switch lead and trim position switch lead (if applicable). Insert hydraulic hose thru opening in transom and place gimbal housing in position. (Figure 2)

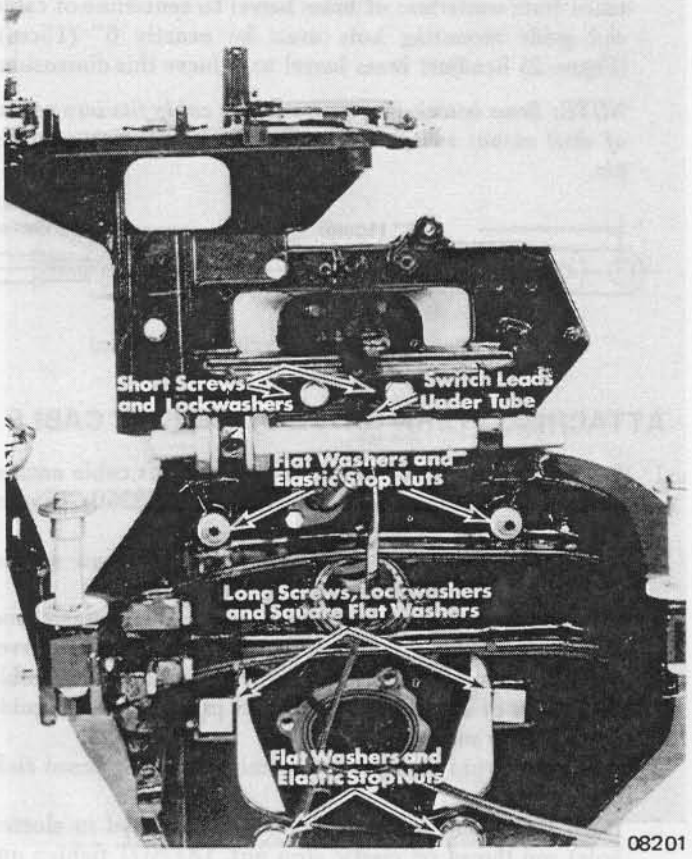


Figure 2. Inner Transom Plate Positioned on Transom

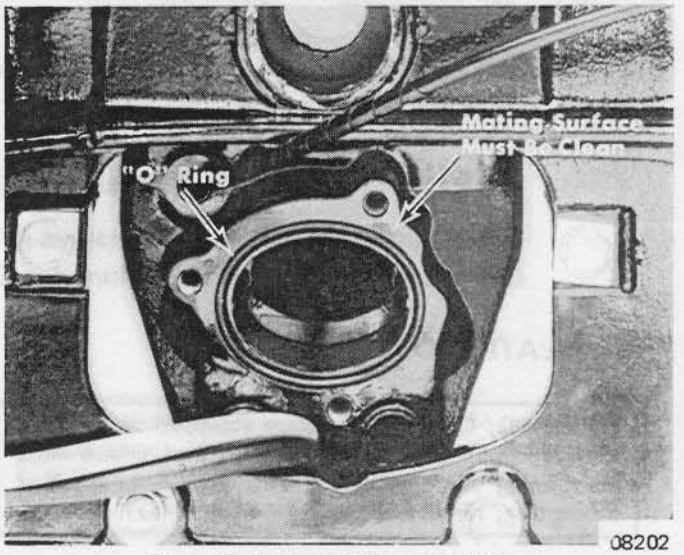


Figure 3. Exhaust Elbow "O" Ring

NOTE: Hydraulic hose must be positioned on port (left) side of exhaust elbow.

CAUTION: If gimbal housing is held in position by the trim limit switch leads while fastening inner transom plate, switch lead or switch could be damaged.

   b. While holding gimbal housing in this position, insert shift cable and hydraulic hose thru large opening, then insert trim limit switch leads and trim position switch lead (if applicable) thru center hole of 3 small holes on inner transom plate, and set plate in position. Route switch leads between inner transom plate and steering cable guide tube. (Figure 2)
3. Fasten gimbal housing assembly and inner transom plate to transom as follows:
   a. Thread 2 short cap screws with lockwashers thru top 2 holes of inner transom plate into gimbal housing. (Figure 2)

b. Insert 2 special anode head bolt assemblies with rubber seals between bolt and gimbal housing thru bottom 2 holes of gimbal housing, transom and inner transom plate.
c. Place flat washers on 2 studs, which protrude thru inner transom plate, and thread on 2 elastic stop nuts.

CAUTION: DO NOT attempt to drive cap screws thru transom, as threads in gimbal housing wil be damaged.

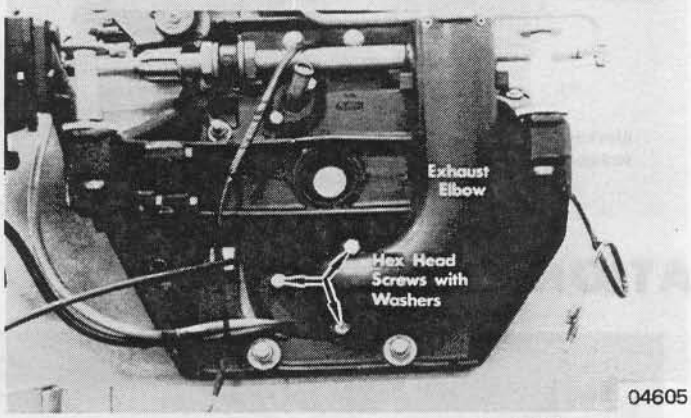


Figure 4. Installing Exhaust Elbow to Gimbal Housing

d. Thread 2 long cap screws with square flat washers and lockwashers thru remaining holes in inner transom plate into gimbal housing. Square washers should be against transom plate.

4. Tighten transom plate cap screws and elastic stop nuts EVENLY, starting from the center working up, then down. Torque to specifications.

5. Install cast exhaust elbow to gimbal housing in the following manner:

   a. Make sure that mating surfaces on exhaust elbow and gimbal housing are clean and that "O" ring is properly seated in groove in gimbal housing. (Figure 3)

   b. Place lockwashers on hex head screws and install exhaust elbow to gimbal housing. (Figure 4) Torque screws to specification.

CAUTION: Be sure that "O" ring remains seated in groove (to properly seal joint) or leakage will result.

6. Place hose clamps over rubber exhaust tube and place tube on cast exhaust elbow. Tighten hose clamps securely.

SHIFT CABLE INSTALLATION and ADJUSTMENT

IMPORTANT: Because of Differences in Shifting Mechanisms, DO NOT USE This New Shift Cable and Adjustment Procedure for Earlier MerCruiser 120-140-165 Stern Drive Units.

INSTALLATION DIMENSIONS

WARNING: On power package equipped with Quicksilver vacuum-operated Power Shift unit, engine must be running while adjusting shift cables. As a safety precaution, remove propeller if boat is NOT in water.

To obtain maximum adjustability on remote control shift cable, check the following dimensions on drive unit shift cable:

1. With cable end guide removed, shift unit in full forward gear. While shifting, turn propeller shaft counterclockwise until shaft stops, to assure full clutch engagement. Inner core wire of drive unit shift cable must extend exactly 1-3/8" (3.5cm) from end of cable guide insert. (Figure 1)

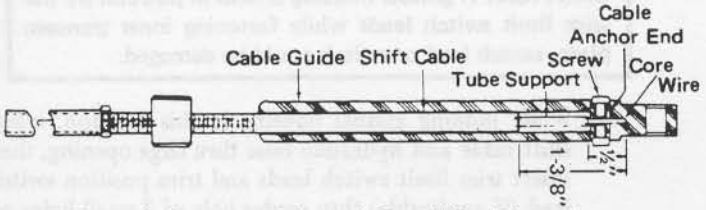


Figure 1. Support Tube and Core Wire Dimensions

   Slide support tube over core wire so that ½" (12.7mm) of core wire is shown. (Figure 1) It is secured to core wire by crimping.
2. Slide cable end guide over end of cable thru cable anchor.
3. Snug one anchor screw and tighten the other to secure core wire. (Figure 1)
4. With cable end guide installed, shift unit in full forward gear. While shifting, turn propeller shaft counterclockwise until shaft stops, to assure full clutch engagement. Distance from centerline of brass barrel to centerline of cable end guide mounting hole must be exactly 6" (15cm). (Figure 2) Readjust brass barrel to achieve this dimension.

   NOTE: Brass barrel of drive unit shift cable fits into recess of shift cutout switch lever and is secured with a cotter pin.

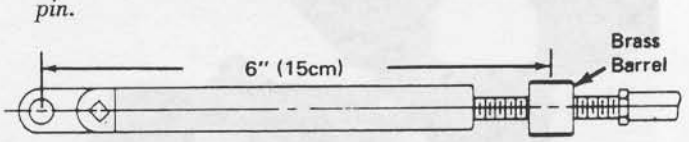


Figure 2. Centerline to Centerline 6" (15cm)

ATTACHING STERN DRIVE UNIT SHIFT CABLE

1. Coat recess of cutout switch lever and shift cable anchor points with Multipurpose Lubricant (C-92-63250). (Figure 3)
2. Route shift cable in cable clamp (located on engine flywheel housing cover) and bend clamp shut.
3. Remove cotter pin from shift cutout lever recess and remove elastic stop nut and flat washer from shift lever adjustable stud. Place brass barrel of drive unit shift cable into recess of shift cutout lever and place cable end guide on shift lever stud. (Figure 3)
4. Insert cotter pin thru cutout switch lever and spread ends of pin.
5. Place flat washer on shift lever stud (located in slotted hole) and thread on elastic stop nut. DO NOT tighten nut securely, as end guide must pivot freely on stud. (Figure 3)

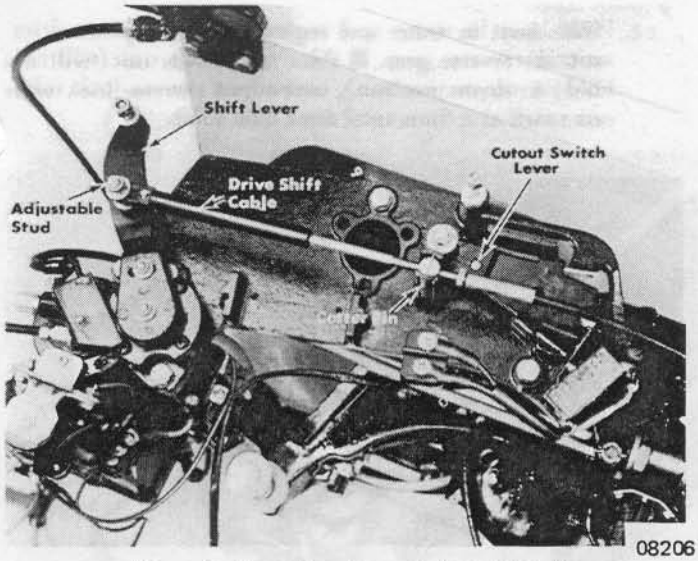


Figure 3. Installing Drive Unit Shift Cable

INSTALLING and ADJUSTING REMOTE CONTROL SHIFT CABLE

IMPORTANT: Remote control shift cable may be installed from right (starboard) or left (port) side of boat. If shift cable is installed from right side, cable brass barrel is installed on shift lever mounting stud. (Figure 4) If shift cable is installed from left side, cable brass barrel is installed on anchor stud (located on inner transom plate). Shift adjustments are the same. Following figures are of RIGHT HAND installation.

NOTE: Before beginning shift adjustment, adjustable stud (Figure 3 - anchor point for drive unit shift cable) MUST BE to bottom of slot in shift lever. (Bottom of slot is toward reverse lock valve.)

1. Remove 2 elastic stop nuts and 2 flat washers from remote control shift cable anchor studs. DO NOT remove 2 of the washers from the shift plate anchor stud and DO NOT remove spacer from anchor stud on shift lever.

   NOTE: Lubricate cable attaching sleeves and studs with Multipurpose Lubricant (C-92-63250).

2. Shift drive unit into full forward by moving the shift lever to the right (when viewing lever from inside boat) as far as it will go. While shifting, turn propeller shaft counterclockwise until shaft stops, ensuring full clutch engagement.
3. Move remote control shift handle to full forward position.
4. Route remote control shift cable from right (starboard) side of engine.
5. Adjust and attach remote control shift cable as follows:
   a. Lightly pull brass barrel away from remote control shift cable end guide (to eliminate slack in cable).
   b. Adjust brass barrel on remote control shift cable to align brass barrel guide with anchor stud on shift lever and cable end guide with anchor stud on shift plate.
   c. After remote control shift cable has been aligned with anchor studs, back brass barrel off 4 turns (away from cable end guide). (Figure 4)
   d. Install shift cable on anchor studs and secure with flat washers and elastic stop nuts. (Figure 4)

IMPORTANT: DO NOT tighten elastic stop nuts against cable, as end guide and brass barrel must pivot freely on anchor studs.

6. Move remote control shift handle to full reverse position while turning propeller shaft clockwise until shaft stops, ensuring full clutch engagement.
7. Check shift cutout switch lever position. (Figure 5) If lever is deflected from its neutral position (center of slot), adjust remote control cable brass barrel one turn at a time (4 turns MAXIMUM) toward end guide until shift cutout switch lever is positioned in center of switch actuating arm slot.

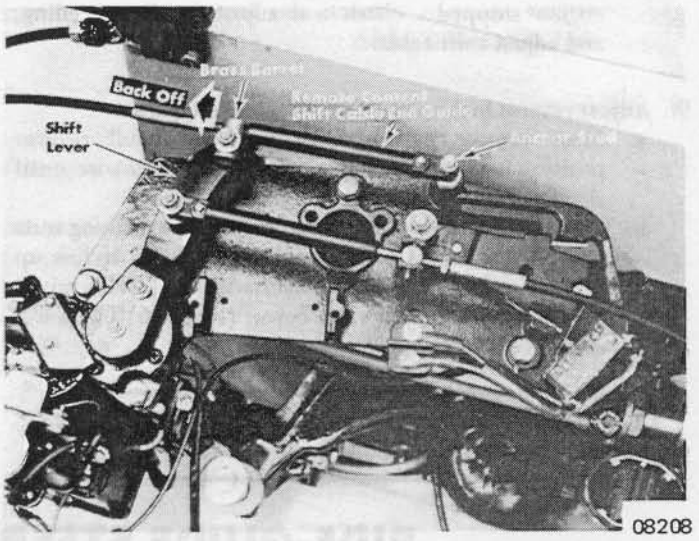


Figure 4. Installing and Adjusting Remote Control Shift Cable

IMPORTANT: If a standard MerControl (side mount) or extra long remote control cables are used, or if there are a large number of bends in remote control shift cable, an additional adjustment may be necessary.

8. Perform following check to determine if further shift adjustment is required. If adjustment is necessary, adjust as follows:
   a. **Out of water, engine stopped - check and adjustment:** Move remote control shift handle into reverse position until throttle BEGINS to open. Turn propeller shaft clockwise. Clutch should engage and cause propeller to lock. If clutch does not engage, loosen adjustable stud, which anchors drive unit shift cable to shift lever, and move it forward in shift lever slot until firm clutch engagement is obtained. Recheck shift cutout switch

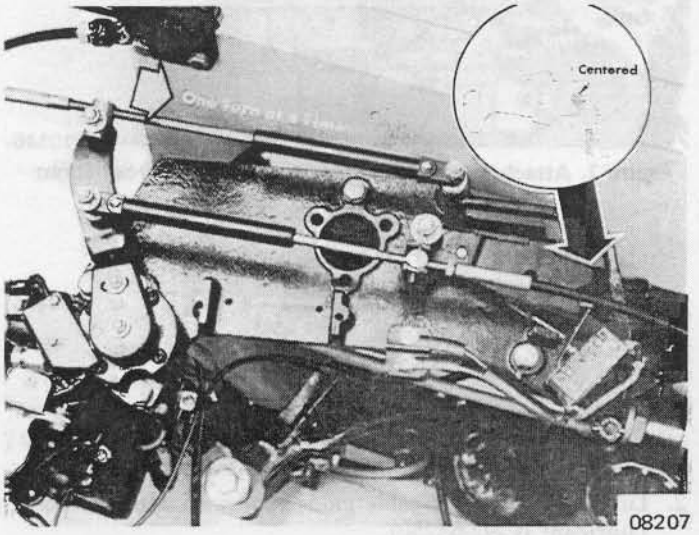


Figure 5. Checking and Adjusting Shift Cutout Switch Lever Location

lever. (Figure 5) Lever must be in neutral position (center of slot in switch actuating arm). Tighten adjustable anchor stud at necessary location of shift lever slot.

b. **In the water, engine running - check and adjustment:** With engine running, move remote control shift handle into reverse position. Reverse clutch should engage BEFORE throttle BEGINS to open. If throttle opens before reverse clutch engages, refer to "Out of water, engine stopped - check and adjustment", preceding, and adjust shift cable.

9. Adjust reverse lock valve (if applicable) as follows:
   a. Move remote control shift handle to full reverse position while turning propeller shaft clockwise until shaft stops, ensuring full clutch engagement.
   b. Loosen 2 shift lever to reverse lock valve attaching nuts and move forward nut in direction required to line up raised triangular mark on cam with SECOND raised mark on reverse lock valve cover. (Figure 6) Tighten 2 shift lever attaching nuts.

CAUTION: Drive unit may be locked in neutral if reverse lock valve is over-adjusted.

c. With boat in water and engine running, operate drive unit in reverse gear. If drive unit trails out (will not hold in down position), over-adjust reverse lock valve one mark at a time until drive unit holds.

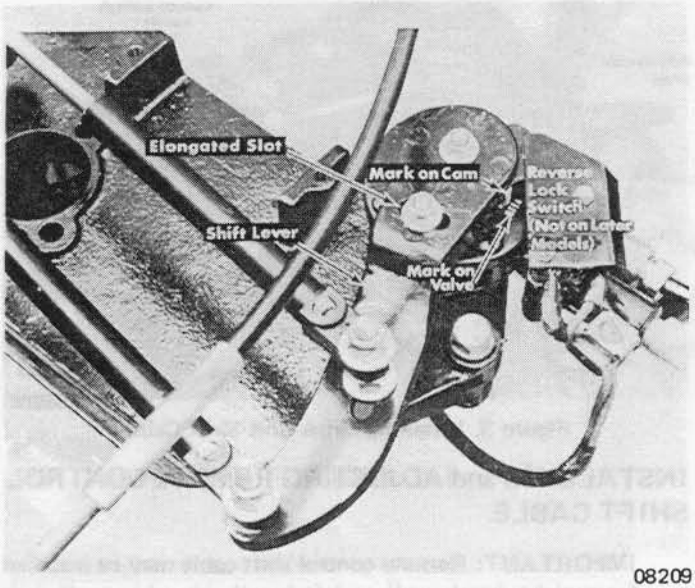


Figure 6. Adjusting Reverse Lock Valve (if Applicable)

RIDE-GUIDE STEERING INSTALLATION

NOTE: Steering cable can be attached to drive unit from either right (Figure 1) or left (Figure 3) side.

1. Attach steering link rod thru hole located in end of steering lever on drive unit. Secure rod to lever with special sleeve, thin washer and castle nut. Torque nut to specification (DO NOT over-torque) and, if necessary, back nut off slightly to install cotter pin.

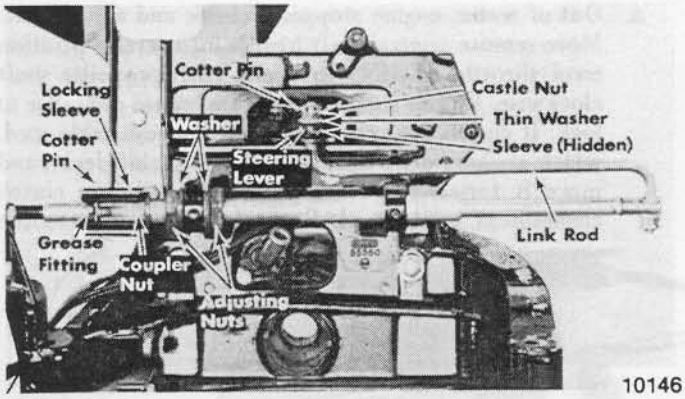


Figure 1. Attaching Steering Cable to Drive Unit from Right

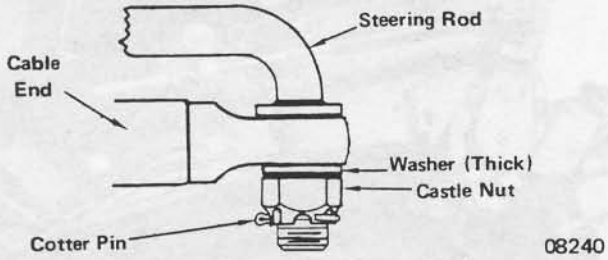


Figure 2. Steering Link Rod Attached

2. Lubricate inside of cable guide tube with Multipurpose Lubricant (C-92-63250).
3. Insert cable end thru tube and thread coupler nut on tube and tighten securely.

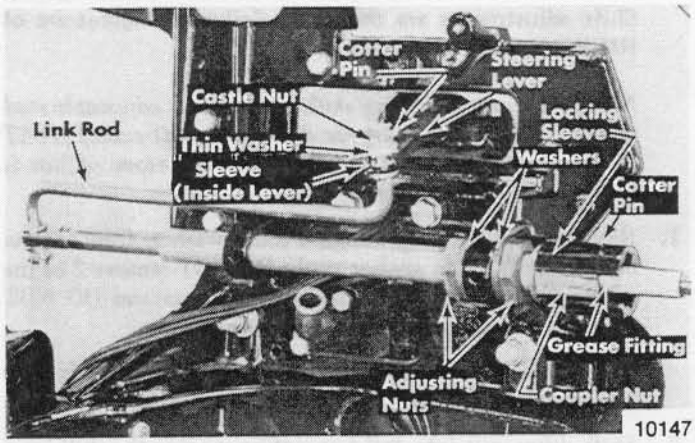


Figure 3. Attaching Steering Cable to Drive Unit from Left

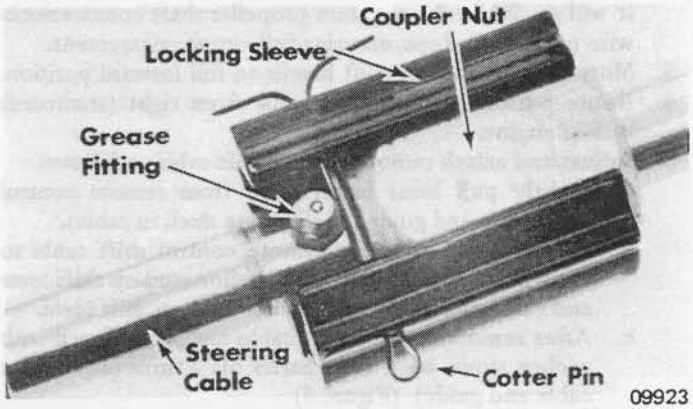


Figure 4. Locking Sleeve Installed on Coupler Nut

4. Install steering cable coupler nut locking device (Figure 4) as follows:
   a. Position rubber bumper into locking sleeve, inserting bumper locating pin into hole provided (if not already installed).

b. Position locking sleeve over steering cable at cable coupler nut end. Slide locking sleeve over coupler nut, as shown in Figure 4. Secure locking sleeve with cotter pin. Pin must be located between grease fitting and cable coupler nut. Spread ends of cotter pin.

NOTE: When installing locking sleeve on Power Steering equipped in-line engines, interference with hydraulic lines may exist. In this case, longer hydraulic lines (B-32-78895 and B-32-78896) MUST BE installed before installing locking sleeve.

5. Attach steering link rod to cable end, using thick washer as shown in Figure 2. Torque castle nut to 20-25 in. lbs. (23-29kg-cm) and, if necessary, back off nut slightly to install cotter pin.
6. Steering tube is pre-set and torqued at the factory. If adjustment is necessary, see "Adjusting Steering (Ride-Guide)", following, after engine and drive unit are installed.

ADJUSTING STEERING (RIDE-GUIDE)

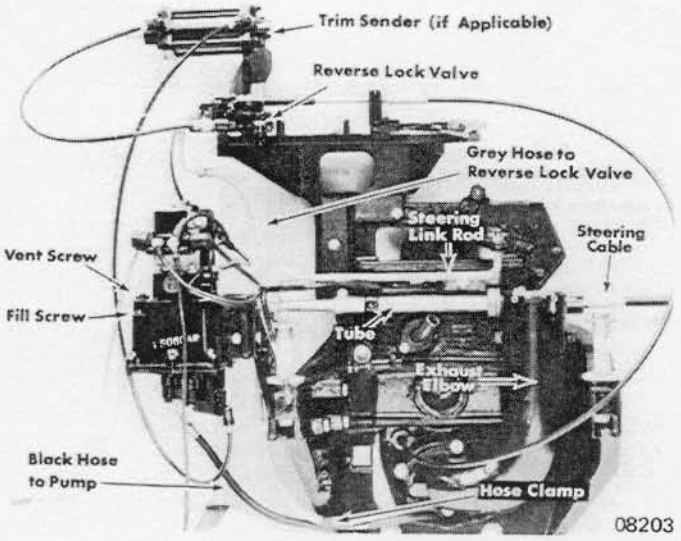
1. Turn steering wheel to full left and right. Drive unit should traverse fully in both directions. If unit turns further in one direction than other, loosen adjusting nuts and move cable guide tube left or right to allow full traverse. Torque adjusting nuts to 35-to-40 ft. lbs. (4.84-to-5.53mkg). [Figures 1 and 3 under "Steering Installation (Ride-Guide)", preceding.]
2. Turn steering wheel until drive unit is centered. If, at this point, steering wheel is not centered correctly, adjust cable guide tube slightly either way to center steering wheel. Recheck Item 1, immediately preceding, after making the adjustment.

TRIM SENDER INSTALLATION

1. Install hydraulic trim sender (if applicable) to transom with two 9/32" (7.14mm) spacers between trim sender bracket and transom and 2 lockwashers and lag screws.
2. Insert hydraulic trim sender lines as shown in Figure 5.

INSTALLING HYDRAULIC HOSES

1. Remove cap from fitting (located on end of black hydraulic hose) and remove threaded plug from pump. (Figure 5)



2. Immediately connect hose to pump.
3. Remove cap from fitting (located on end of gray reverse lock valve hydraulic hose) and remove threaded plug from valve. (Figure 5) DO NOT allow oil to run out of hose and pump. Tighten fittings securely.
4. Clamp hydraulic hoses securely to transom plate at location shown in Figure 5.

IMPORTANT: Failure to comply with preceding Steps 1, 2, 3 and 4 may cause hydraulic hose to become damaged and render hydraulic system inoperative.

5. Loosen pump reservoir vent screw. (Figure 5) Vent must be open for proper operation.
6. With unit down all the way in normal operating position, check oil level by removing "Fill" screw. If necessary, fill to bottom of threads with an SAE 5W-20 or SAE 5W-30 specification "SE" automotive oil. Do not overfill.
7. Replace "Fill" screw.

Figure 5. Hydraulic Hoses Installed

SECTION 2 - REMOVAL, INSTALLATION and ALIGNMENT

mercruiser

PART B - V-8 I-DRIVE MODELS

08524

MERCURY MARINE

A BRUNSWICK COMPANY

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MERCRUISER V-8 I-DRIVE ENGINE

Removal

NOTE: Stern drive must be removed prior to engine removal. Refer to "Stern Drive Removal" (use "Index").

1. Disconnect battery cables from battery and remove instrument panel harness connector plug from engine harness receptacle.
2. Disconnect fuel line and throttle cable.
3. Remove shift cables (drive unit and remote control) from shift plate, then remove cables from "J" clamp (located on exhaust manifold).
4. Disconnect reverse lock switch wires from trim pump and trim pump red and black wires from engine or battery.
5. Disconnect water inlet hose and exhaust elbow bellows.
6. Remove gray "down" hose from reverse lock and black plastic hose from trim sender. Cap hoses and plug hose connections.
7. Disconnect any accessories that are connected to engine.
8. Support engine with suitable sling thru lifting eyes on engine and remove front and rear engine mounting bolts.
9. Carefully remove engine.

Installation and Alignment

NOTE: The transom plates and exhaust elbows must be installed before proceeding with "Engine Installation and Alignment". Refer to "Stern Drive Installation".

1. Place one double-wound lockwasher and one fiber washer on top of each inner transom plate engine support. (Fig. 1)

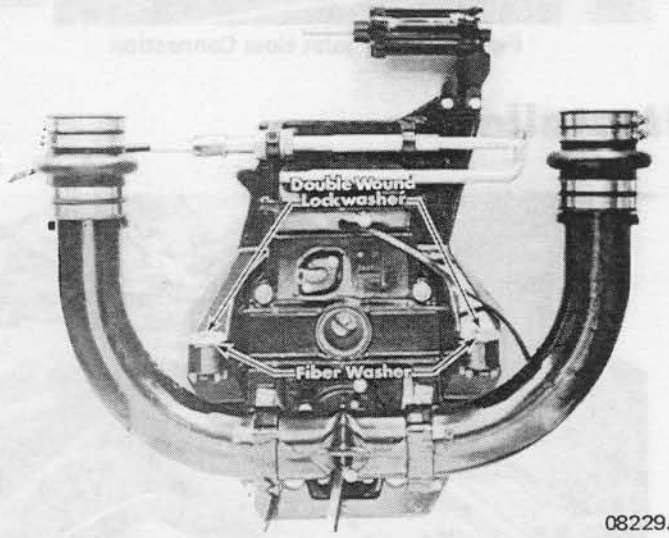


Figure 1. Washers Positioned on Transom Plate Engine Supports

2. Lift engine with an overhead hoist, using a suitable sling and lifting eyes on engine. Engine must be suspended so that rear end is slightly lower than front, and front mounts are level.

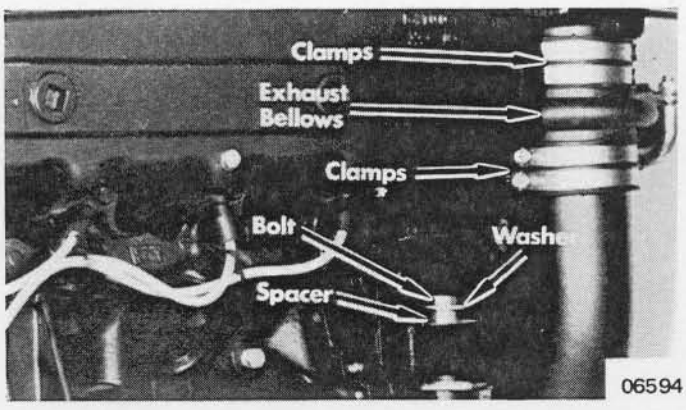


Figure 2. Exhaust Bellows Installed

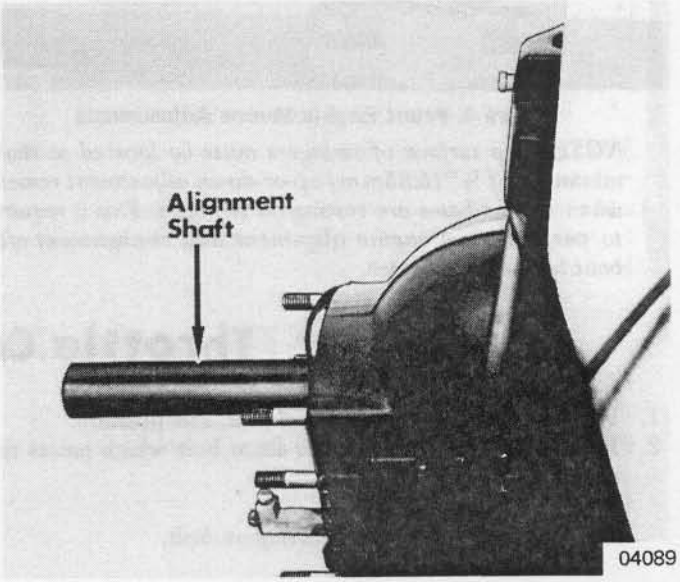


Figure 3. Alignment Shaft Installed

3. Lower engine into position over transom plate and, while lowering, connect exhaust bellows to exhaust elbows. Allow rear engine mounts to rest on transom plate engine supports. Do not relieve hoist tension.
4. Place one steel washer and one spacer on each rear mount bolt and insert bolts down thru engine mounts, washers and mounting brackets. Thread elastic stop nuts on bolts and tighten to specification. (Figure 2)
5. Tighten exhaust bellows clamps securely. (Figure 2)
6. Insert end of Alignment Tool (C-91-57797A3) shaft (end without threaded hole) thru gimbal bearing. (Figure 3) Move gimbal bearing with shaft to align shaft with coupling spline and raise or lower front of engine with hoist to allow shaft to enter spline (and bottom out) freely.

   NOTE: If engine mount bases contact stringers when lowering front of engine, loosen locking nut "A" and turn mount adjusting nut "B" (Figure 4) counterclockwise to raise mounts up, away from stringers. Preliminary alignment must be made with front of engine supported evenly with hoist and mount bases not contacting stringers.

7. After preliminary alignment has been attained, remove alignment shaft and turn adjusting nuts ("B" on both front

mounts) clockwise to lower mounts (Figure 4) until mount contacts top of stringers. At this point, stop turning nuts and place a reference mark on each adjusting nut "B". Turn each nut clockwise one more full turn.

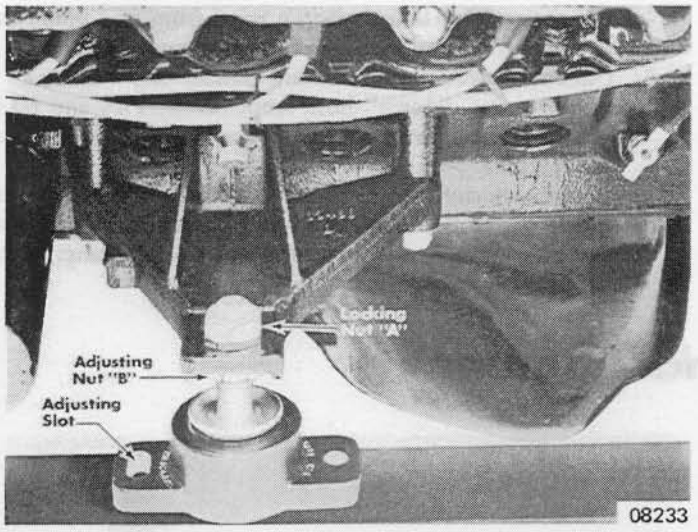


Figure 4. Front Engine Mount Adjustments

NOTE: Top surface of stringers must be located so that a minimum of ¼" (6.35mm) up-or-down adjustment remains when mount bases are resting on stringers. This is required to perform final engine alignment and re-alignment after boat has been in service.

8. Relieve hoist tension entirely and fasten front mounts (with slotted mounting hole toward front of engine) to engine stringers. Use 3/8" (9.5mm) diameter lag bolts of sufficient length.
9. Recheck alignment shaft fit. Shaft must enter engine coupling freely. If not, turn both front mount adjusting nuts "B" an equal amount by alternating from one side to the other until shaft enters coupling spline (and bottoms out) freely.
10. Place hose clamp on water inlet hose and connect hose to water inlet tube. Tighten hose clamp securely. (Figure 5)

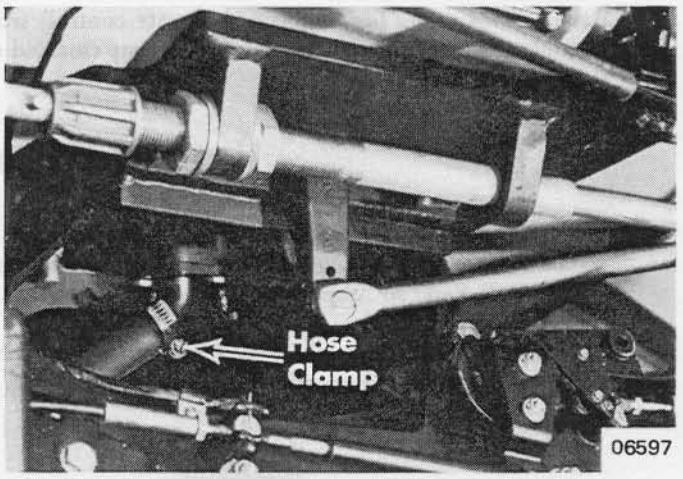


Figure 5. Water Inlet Hose Connection

Throttle Cable Installation

1. Place remote control in neutral gear, idle position.
2. Remove nut and thin washer from bolt which passes thru carburetor throttle lever.

   NOTE: Leave spacer and bushing on bolt.

3. Place cable end guide over bushing. Place flat washer on bolt and tighten nut securely. (Figure 6)
4. Grasp throttle cable at point behind brass barrel and push toward throttle lever. Adjust brass barrel to align with anchor stud. Fasten barrel to stud with flat washer and nut. Tighten nut securely.

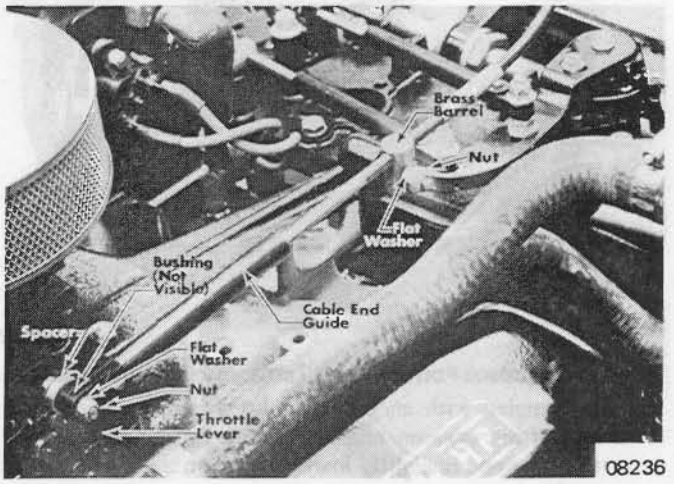


Figure 6. Throttle Cable Installed

STERN DRIVE UNIT
Removal

1. Shift drive unit into full forward.
2. Disconnect rear end of trim cylinders from drive unit.
3. Support drive unit with suitable sling thru lifting eye on top cover and remove 6 nuts which hold drive unit to bell housing.
4. Carefully remove drive unit.
5. Remove and discard drive shaft housing to bell housing gasket.

Installation of Stern Drive Unit

CAUTION: Check Engine Alignment with Engine Coupler Alignment Shaft (C-91-48247 or C-91-57797A3) before Installing Stern Drive Unit. (Refer to "Engine Installation and Alignment".)

1. Lubricate shifting slide assembly (Figure 1) with Multipurpose Lubricant (C-92-63250).

   NOTE: Slide assembly is free to rotate on core wire, so be sure that slide is located in the upright position during installation.

CAUTION: Be sure that rubber gasket is in place, or water will leak into bellows. (Figure 1)

Figure 1. Lubricating Shifting Slide Assembly

2. Lubricate drive shaft housing pilot (Figure 2) with Multipurpose Lubricant (C-92-63250), and U-joint splines with Universal Joint Lubricant (C-92-74058).

CAUTION: If locating slot of shift lever in bell housing and coupler of intermediate shift shaft in drive shaft housing are not aligned as described in Steps 3 and 4, following, bell housing and shift shaft couplers will be damaged when drive unit is installed.

3. Align locating slot of shift lever coupler in bell housing straight to rear by moving shift lever to the right (facing transom from inside boat) and lubricate slot with Anti-Corrosion Grease (C-92-74048).
4. Align coupler of intermediate shift shaft in drive shaft housing for straight entry into locating slot of shift lever in gimbal housing.

   NOTE: It may be necessary to rotate propeller shaft to align intermediate shift shaft coupling with upper shift shaft slot.

5. Drive unit must be in forward gear position. Lubricate coupler surface with Perfect Seal (C-92-34227).

   NOTE: Since the fit between the universal joint yoke "O" rings and gimbal housing ball bearing is tight, it is recommended that a coating of Multipurpose Lubricant be placed on the 2 "O" rings. This will facilitate installation of the universal joint yoke into the gimbal housing ball bearing.

6. Place drive shaft housing gasket on bell housing. (Figure 2)

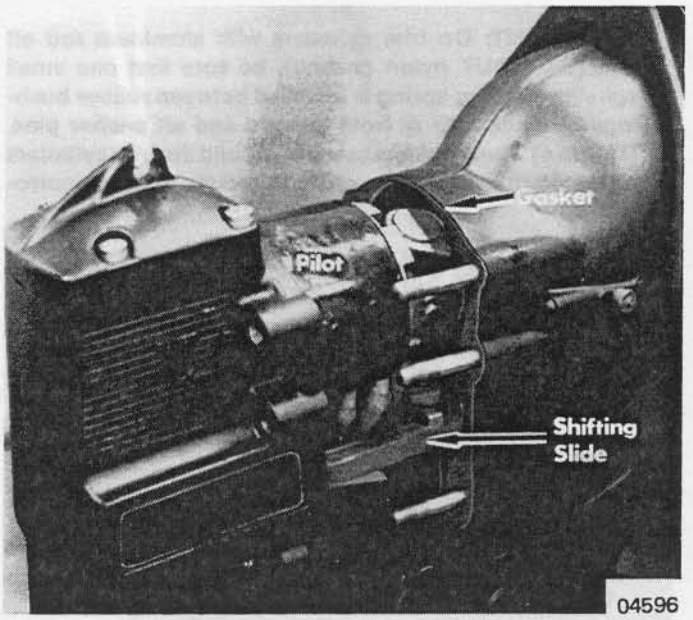


Figure 2. Lubricating Drive Shaft Housing Pilot

7. Insert stern drive unit into drive shaft housing bell bore as follows: (Figure 2)
   a. Guide universal joint shaft thru bearing in gimbal housing into drive coupling on engine. Also guide shift slide into opening in drive shaft housing.
   b. Be careful not to move shift slide assembly or shift shaft coupler. Shift shafts will not align if out of position. If universal joint shaft splines do not align with engine coupling splines, rotate propeller shaft counterclockwise until drive unit can be pushed into position. Propeller should be placed on shaft for easier rotation. DO NOT rotate propeller shaft clockwise, or drive unit shift shaft will turn out of forward position.
9. Fasten drive shaft housing to bell housing studs with 6 flat washers and elastic stop nuts. Tighten evenly to specification. (Figure 3)

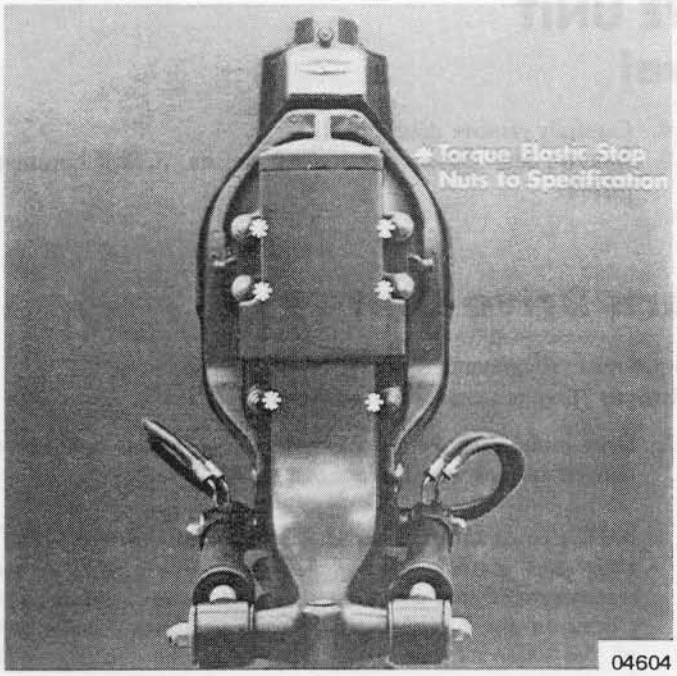


Figure 3. Fastening Drive Shaft Housing to Bell

INSTALLING TRIM CYLINDERS

IMPORTANT: On trim cylinders with aluminum rod aft end (WITHOUT nylon coating), be sure that one small spiral grounding spring is installed between rubber bushings on each side of both forward and aft anchor pins. (Figure 4) They are necessary to ground the trim cylinders to the stern drive unit in order to reduce galvanic corrosion.

NOTE: Forward anchor pin is installed previously. Refer to "Transom Plate Installation" (see "Index").

1. Insert aft anchor pin thru hole in drive shaft housing and place one large washer, one rubber bushing and one spiral spring (if applicable) on aft anchor pin on each side of drive shaft housing. (Figure 4)
2. Loosen nuts, which retain hydraulic cylinders to forward anchor pin, and place cylinders in position on aft anchor pin.
3. Place one rubber bushing in aft end mounting of each cylinder. Small diameter end of bushings face drive shaft housing.
4. Place one flat washer on each end of both cylinders next to rubber bushings. Thread nuts on anchor pins. Tighten nuts on FORWARD AND AFT anchor pins securely. (Figure 5)

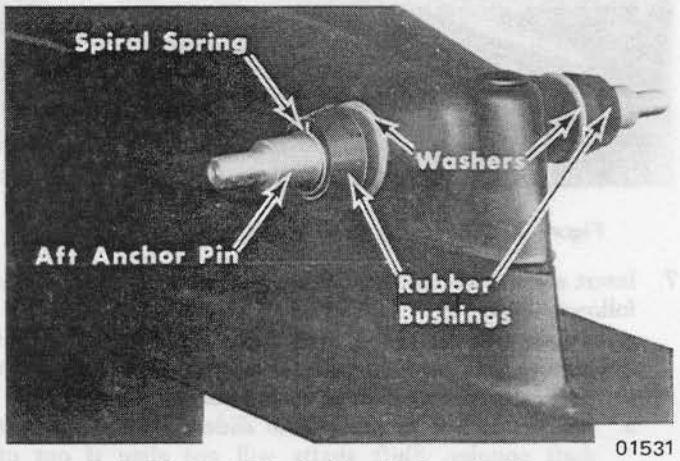


Figure 4. Aft Anchor Pin Installed

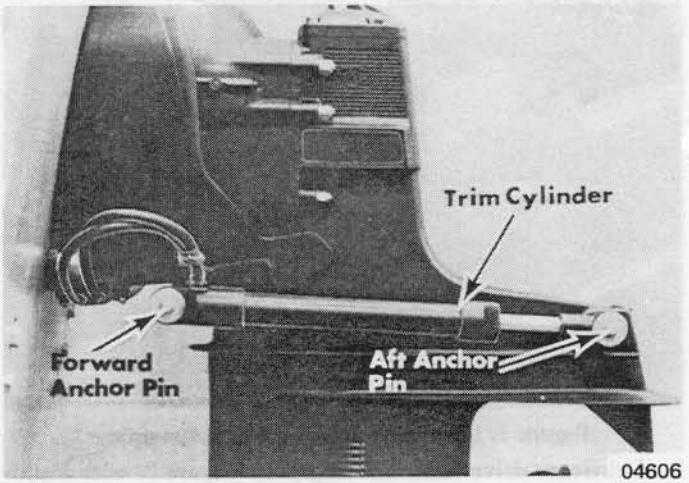
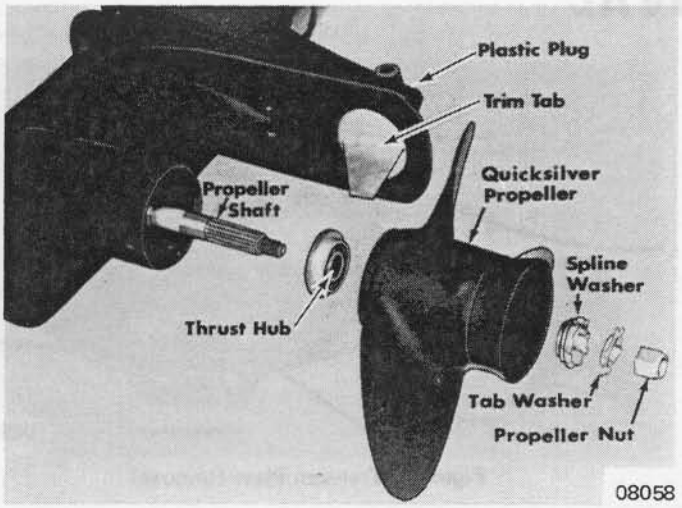


Figure 5. Power Trim Cylinder Installed

PROPELLER INSTALLATION



1. Apply a liberal coat of Perfect Seal (C-92-34227) on splines of propeller shaft, especially if operated in salt water, to aid in removing at any future time.
2. Place thrust hub and washer assembly into propeller hub (shoulder into recess of propeller).
3. While aligning splines, place jet-prop propeller (with thrust hub assembly) and spline washer on propeller shaft in this order. (Figure 6)
4. Place propeller nut in groove of tab washer, thread propeller nut on propeller shaft and torque to specification.
5. Bend 3 of the tabs of tab washer down in grooves of spline washer to secure propeller nut.

Figure 6. Installing and Removing Propeller

TRANSOM PLATE ASSEMBLY

REMOVAL

NOTE: Drive unit and engine must be removed prior to transom plate assembly removal. Refer to "Drive Unit Removal" and "Engine Removal" (use "Index").

1. Remove steering link rod. (Figure 1)
2. Disconnect and remove steering cable from tube.
3. Remove both hydraulic hoses from trim pump. Cap hoses and plug hose connections.
4. Remove exhaust separator (with exhaust elbows and exhaust bellows attached) from gimbal housing.
5. Disconnect tilt limit switch from trim wiring harness.
6. Remove screws and nuts, which hold inner and outer transom plates together, then remove inner transom plate and outer transom plate in that order.

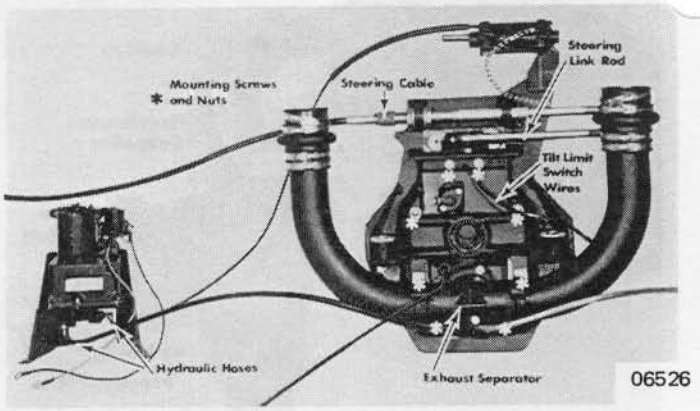


Figure 1. Transom Plate Removal

TRANSOM PLATE INSTALLATION

1. If hydraulic trim cylinders are not installed, install them per instructions following:
   a. Insert forward anchor pin in gimbal ring.
   b. Place one flat washer, one rubber bushing and one spiral spring on each side of forward anchor pin.
   c. Place cylinders in position on forward anchor pin.
   d. Place one rubber bushing, one flat washer and one nut on each end of forward anchor pin. Tighten nuts securely.
2. Set gimbal housing assembly and inner transom plate in position over openings in transom as follows:
   a. Insert shift cable, trim limit switch lead and hydraulic hose thru opening in transom and place gimbal housing in position.

CAUTION: If gimbal housing is held in position by the trim limit switch leads while fastening inner transom plate, switch lead or switch could be damaged.

   b. While holding gimbal housing in this position, insert shift cable and hydraulic hoses thru large opening on inner transom plate and insert trim limit switch leads thru center hole of 3 small holes in inner transom plate, then set plate in position. (Figure 2)
3. Fasten gimbal housing assembly and inner transom plate to transom as follows:
   a. Thread 2 short cap screws with lockwashers thru top 2 holes of inner transom plate into gimbal housing. (Figure 2)
   b. Insert 2 special anode head bolt assemblies with rubber seals placed between bolts and gimbal housing thru bottom 2 holes of gimbal housing, transom and inner transom plate.
   c. Place flat washers on bolts and thread on 2 elastic stop nuts.
   d. Place flat washers on 2 studs, which protrude thru inner transom plate, and thread on 2 elastic stop nuts.

CAUTION: DO NOT attempt to drive cap screws thru transom, as threads in gimbal housing will be damaged.

   e. Thread 2 long cap screws with square flat washers and lockwashers thru remaining holes in inner transom plate into gimbal housing. Square washers should be against transom plate.

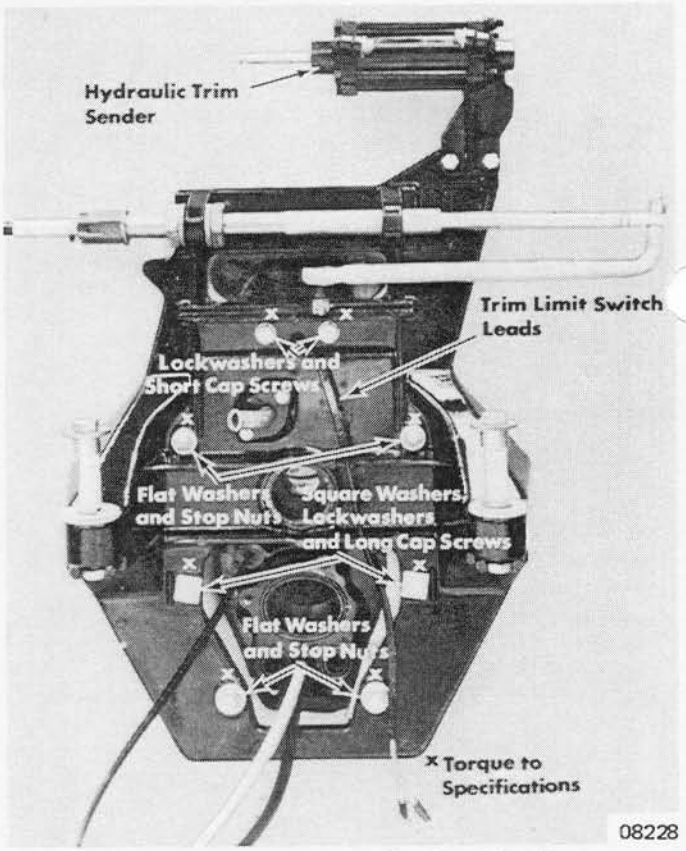


Figure 2. Inner Transom Plate Positioned on Transom

4. Tighten transom plate cap screws and elastic stop nuts EVENLY, then torque to specification. Start by torquing from the center up, then center down. Retorque after a few minutes.
5. Mount hydraulic trim sender assembly on transom plate (Figure 2) with 2 cap screws and lockwashers and tighten securely.
6. Install exhaust separator (with exhaust elbows and exhaust bellows attached) to gimbal housing, following:
   a. Be certain that mating surfaces on exhaust separator and gimbal housing are clean and that "O" rings are properly seated in grooves. (Figure 3)

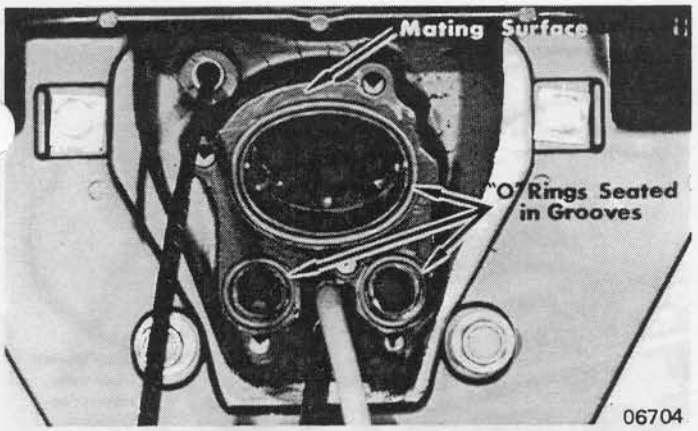


Figure 3. Gimbal Housing "O" Ring Locations

b. Place 4 hex head cap screws and one allen head cap screw with lockwashers thru separator into gimbal housing. (Figure 4) Torque screws EVENLY to specification.

CAUTION: Be sure that "O" rings remain seated in grooves of gimbal housing to properly seal joint, or leakage will occur.

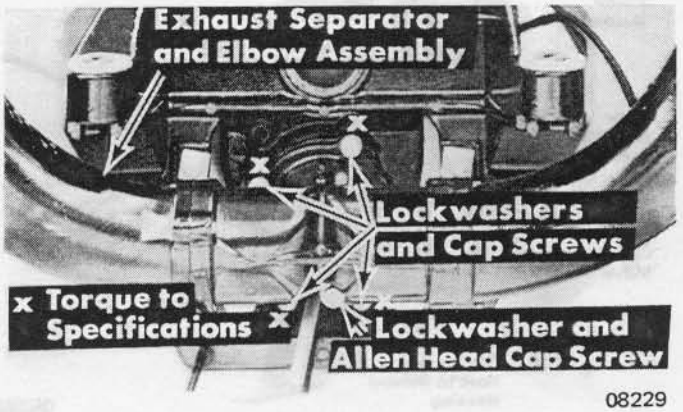


Figure 4. Installing Exhaust Separator and Elbows

HYDRAULIC HOSE CONNECTION

1. Route hydraulic hoses toward pump as shown in Figure 5.
2. Remove cap from hydraulic fitting (located on end of black, gimbal housing hydraulic hose), remove threaded plug from hydraulic pump control valve and immediately connect hose to control valve. (Figures 5 and 6)
3. Connect black "down" hydraulic hose from pump control valve to trim sender (Figure 5) after removing plug from sender and cap from hose.

   NOTE: The gray "down" hydraulic hose and hose to trim sender are connected after engine is installed.

4. Connect gray "down" hydraulic hose from gimbal housing to reverse lock valve after removing cap from hose fitting and plug from valve. (Figure 7)
5. Connect hydraulic hose from reverse lock valve (mounted on shift bracket) to shaft end of trim sender after removing cap from hose and plug from sender. (Figure 7)
6. Loosen pump reservoir vent screw. (Figure 6) Note that vent must be open for proper operation.
7. With drive unit down all the way in normal operating position, check oil level by removing "Fill" screw. (Figure 6) If necessary, fill to bottom of threads with an SAE 5W-20 or SAE 5W-30 specification SE automotive oil. DO NOT overfill.
8. Replace "Fill" screw.

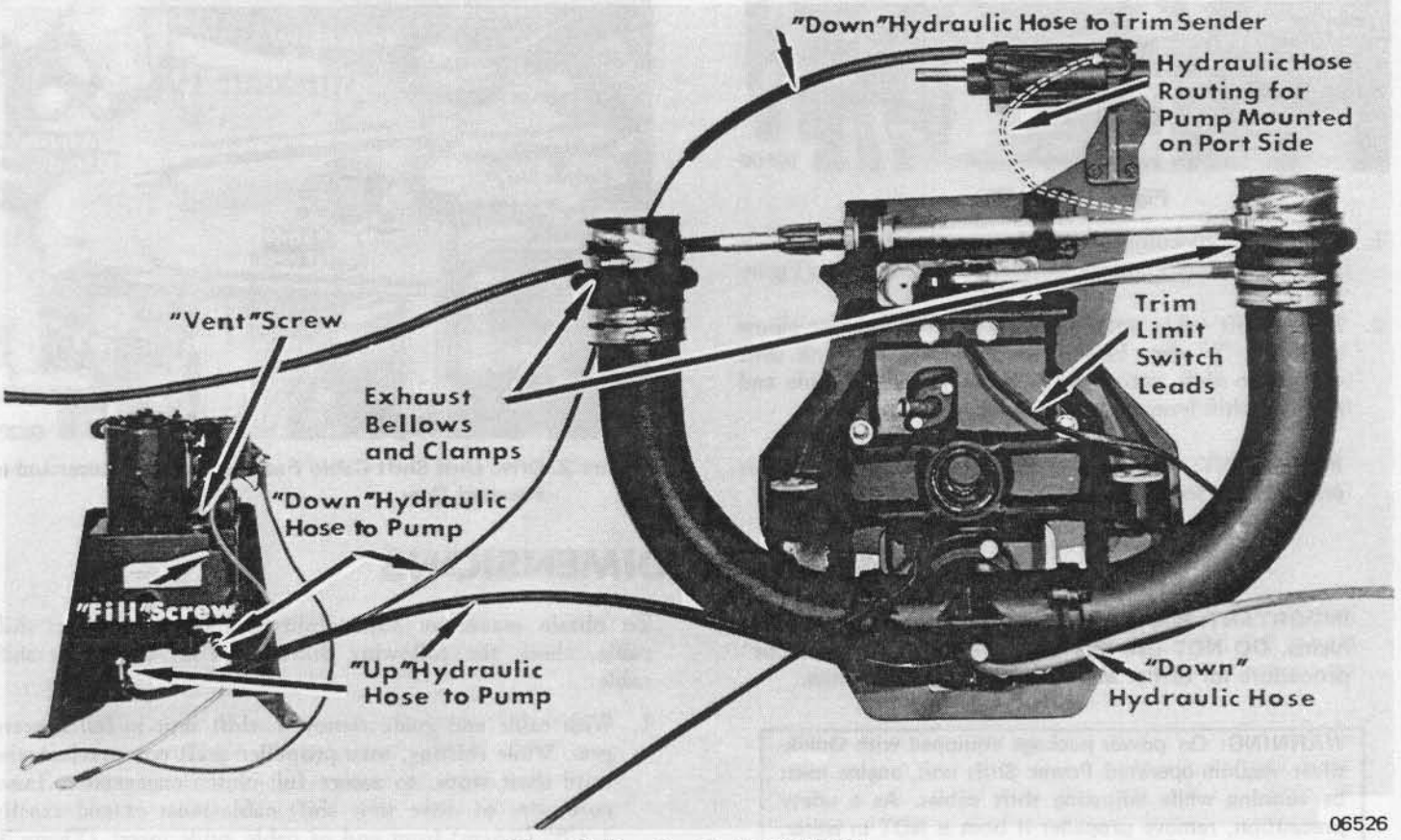


Figure 5. Routing Hydraulic Hoses

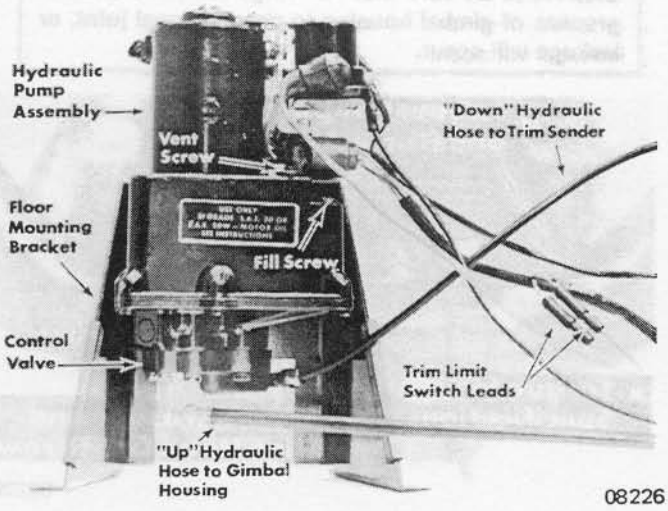


Figure 6. Hydraulic Pump Mounted to Floor of Boat

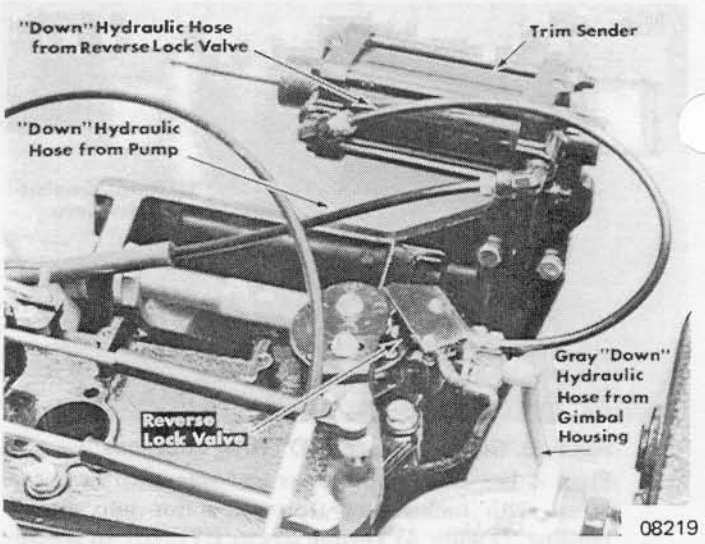


Figure 7. Hydraulic Hoses Connected to Trim Sender and Reverse Lock Valve

ATTACHING STERN DRIVE UNIT SHIFT CABLE

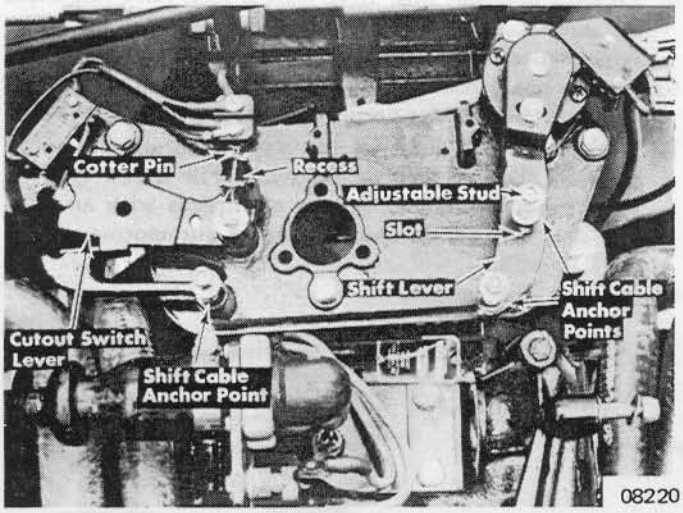


Figure 1. Shift Plate

1. Coat recess of cutout switch lever and shift cable anchor points with Multipurpose Lubricant (C-92-63250). (Figure 1)
2. Route shift cable under right (starboard) exhaust elbow and thru "J" clip. Place brass barrel of drive unit shift cable into shift cutout lever recess and place cable end guide on shift lever stud. (Figure 2)

IMPORTANT: Brass barrel on drive unit shift cable is preset at factory and should not be threaded either way.

NOTE: DO NOT close "J" clip around shift cable. Clip will be bent closed after attaching and adjusting remote control shift cables.

3. Insert cotter pin thru cutout switch lever and spread ends of pin. (Figure 2)
4. Place flat washer on shift lever stud and thread on elastic stop nut. DO NOT tighten nut securely, as end guide must pivot freely on stud. (Figure 2)

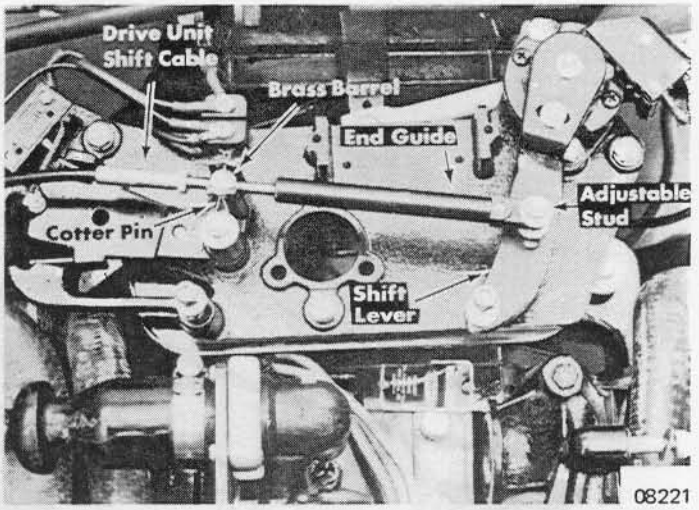


Figure 2. Drive Unit Shift Cable Fastened to Shift Lever and in Forward Gear

INSTALLATION DIMENSIONS

IMPORTANT: Because of differences in shifting mechanisms, DO NOT use this new "Installation Dimensions" procedure for earlier MerCruiser Stern Drive Units.

WARNING: On power package equipped with Quicksilver vacuum-operated Power Shift unit, engine must be running while adjusting shift cables. As a safety precaution, remove propeller if boat is NOT in water.

To obtain maximum adjustability on remote control shift cable, check the following dimensions on drive unit shift cable:

1. With cable end guide removed, shift unit in full forward gear. While shifting, turn propeller shaft counterclockwise until shaft stops, to assure full clutch engagement. Inner core wire of drive unit shift cable must extend exactly 1-3/8" (3.5cm) from end of cable guide insert. (Figure 3)

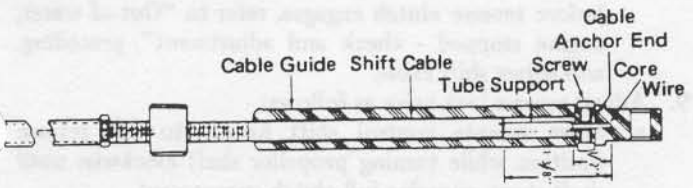


Figure 3. Support Tube and Core Wire Dimensions

Slide support tube over core wire so that ½" (12.7mm) of core wire is shown. (Figure 3) It is secured to core wire by crimping.

2. Slide cable end guide over end of cable thru cable anchor.
3. Snug one anchor screw and tighten the other to secure core wire. (Figure 3)

4. With cable end guide installed, shift unit in full forward gear. While shifting, turn propeller shaft counterclockwise until shaft stops, to assure full clutch engagement. Distance from centerline of brass barrel to centerline of cable end guide mounting hole must be exactly 6" (15cm). (Figure 4) Readjust brass barrel to achieve this dimension.

NOTE: Brass barrel of drive unit shift cable fits into recess of shift cutout switch lever and is secured with a cotter pin.

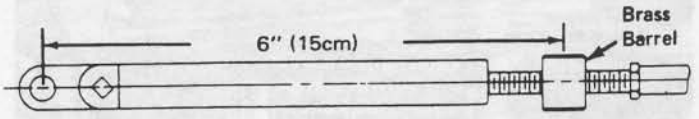


Figure 4. Centerline to Centerline 6" (15cm)

ATTACHING and ADJUSTING REMOTE CONTROL SHIFT CABLE

IMPORTANT: Because of differences in shifting mechanisms, DO NOT use this new attaching and adjusting procedure for earlier MerCruiser 120-140-165 Stern Drive Units.

IMPORTANT: Remote control shift cable MUST be installed as outlined, following, for either right (starboard) side or left (port) side installation of remote control.

Before beginning shift adjustment, adjustable stud (Figure 1 - anchor point for drive unit shift cable) MUST be to rear of slot in shift lever.

1. Shift drive unit into full forward by moving the shift lever (Figure 2) to the right (starboard) side of the boat as far as it will go. While shifting, turn propeller shaft counterclockwise until shaft stops, ensuring full clutch engagement.

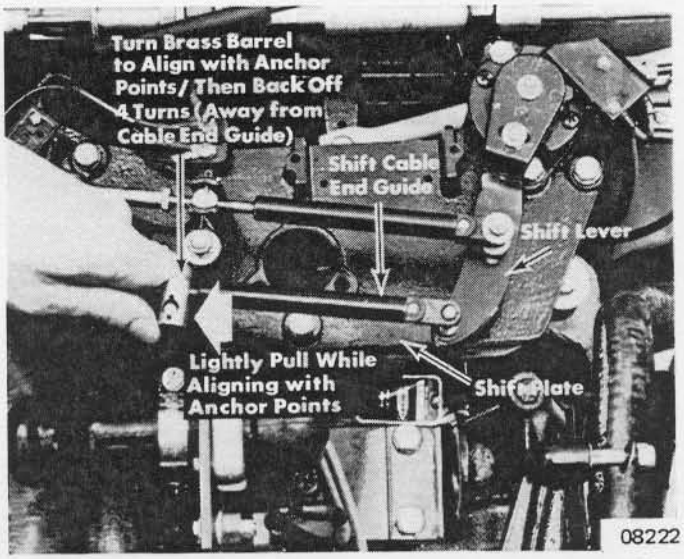


Figure 5. Adjusting Brass Barrel on Remote Control Shift Cable

2. Move remote control shift handle to full forward position.
3. Route remote control shift cable under right (starboard) exhaust elbow and thru "J" clip. Bend "J" clip closed around shift cables. Cables MUST be free to move back-and-forth thru "J" clip.

4. Adjust and attach remote control shift cable as follows:
   a. Lightly pull brass barrel away from remote control shift cable end guide (to eliminate slack in cable). (Figure 5)
   b. Adjust the brass barrel on remote control shift cable to align cable end guide with anchor stud on shift lever and brass barrel with anchor stud on shift plate. (Figure 5)
   c. After remote control shift cable has been aligned with anchor studs, back brass barrel off 4 turns (away from cable end guide). (Figure 5)

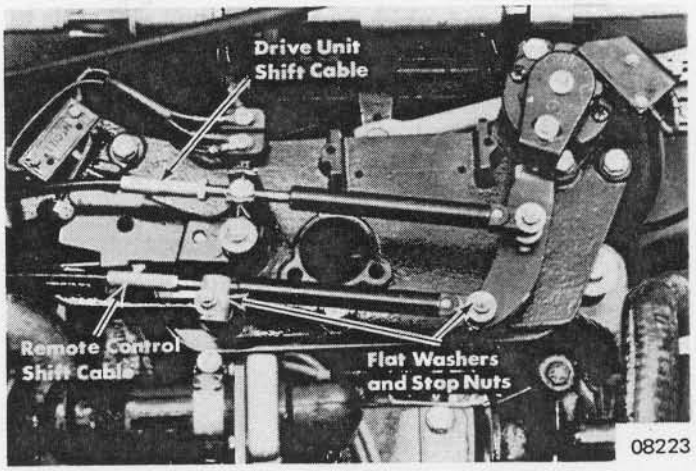


Figure 6. Shift Cables Attached and in Forward Gear

   d. Install shift cable on anchor studs and secure with flat washers and elastic stop nuts. Brass barrel must be installed over spacer on anchor stud. (Figure 6)

IMPORTANT: DO NOT tighten elastic stop nuts against cable, as end guide and brass barrel must pivot freely on anchor studs. (Figure 6)

5. Move remote control shift handle to full reverse position while turning propeller shaft clockwise until shaft stops, ensuring full clutch engagement.
7. Check shift cutout switch lever roller position. (Figure 7) If lever is deflected from its neutral position (roller not in center of notch), adjust remote control cable brass barrel one turn at a time (4 turns MAXIMUM) toward end guide until shift cutout switch lever roller is positioned in center of switch actuating arm notch.

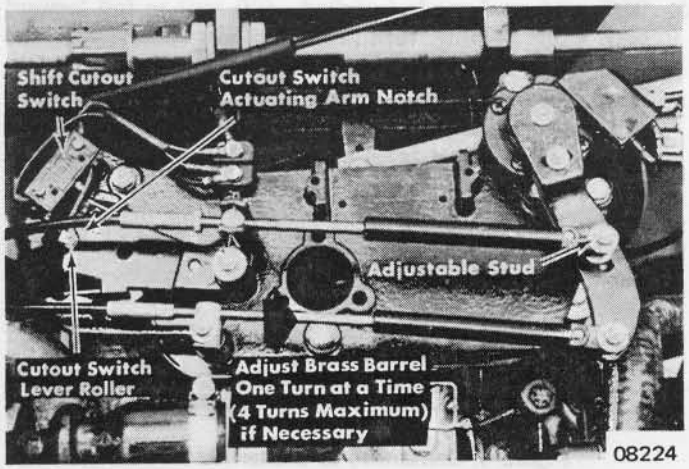


Figure 7. Checking and Adjusting Shift Cutout Switch Lever Location

IMPORTANT: If a standard MerControl (side mount) or extra long remote control cables are used, or if there are a large number of bends in remote control shift cable, an additional adjustment may be necessary.

8. Perform following check to determine if further shift adjustment is required. If adjustment is necessary, adjust as follows:
   a. **Out of water, engine stopped - check and adjustment:** Move remote control shift handle into reverse position until throttle BEGINS to open. Turn propeller shaft clockwise. The clutch should engage and cause propeller to lock. If clutch does not engage, loosen adjustable stud, which anchors drive unit shift cable to shift lever, and move it forward in shift lever slot until firm clutch engagement is obtained. Recheck shift cutout switch lever roller. (Figure 7) Roller must be in neutral position (center of notch in switch actuating arm). Tighten adjustable anchor stud at necessary location of shift lever slot.
   b. **In the water, engine running - check and adjustment:** With engine running, move remote control shift handle into reverse position. Reverse clutch should engage BEFORE throttle BEGINS to open. If throttle opens before reverse clutch engages, refer to "Out of water, engine stopped - check and adjustment", preceding, and adjust shift cable.
9. Adjust reverse lock valve as follows:
   a. Move remote control shift handle to full reverse position while turning propeller shaft clockwise until shaft stops, ensuring full clutch engagement.

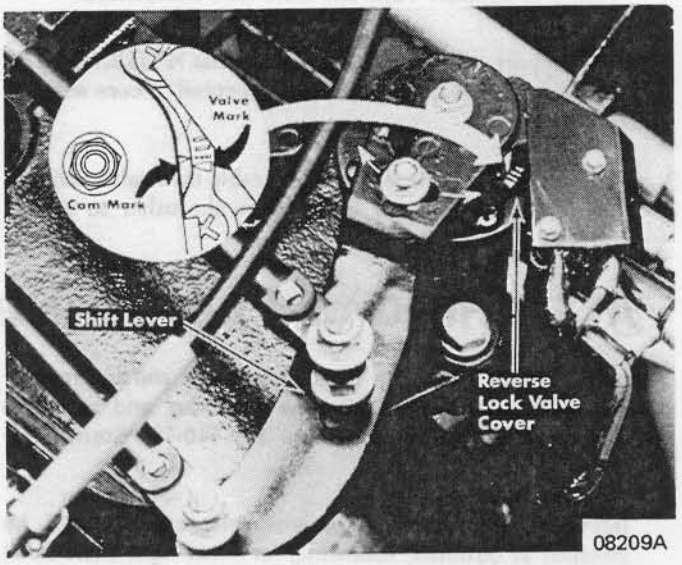


Figure 8. Adjusting Reverse Lock Valve

   b. Loosen 2 shift lever to reverse lock valve attaching nuts and move forward nut in direction required to line up raised triangular mark on cam with SECOND raised mark on reverse lock valve cover. (Figure 8) Tighten 2 shift lever attaching nuts.

CAUTION: Drive unit may be locked in neutral if reverse lock valve is adjusted too far.

   c. With boat in water and engine running, operate drive unit in reverse gear. If drive unit trails out (will not hold in down position), over-adjust reverse lock valve one mark at a time until drive unit holds.

RIDE-GUIDE STEERING INSTALLATION

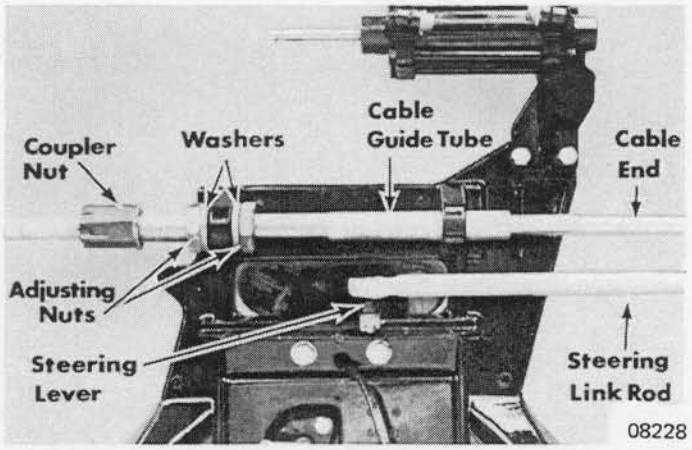


Figure 9. Attaching Steering Cable to Transom Plate from Right

NOTE: Steering cable can be attached to drive unit from either right (Figure 9) or left (Figure 10) side.

1. Connect steering link rod to steering lever with pivot bolt thru rod and nylon washer and wave washer between rod and lever. (Figure 11) Align wave washer with shoulder on pivot bolt and secure with flat washer and castle nut. Torque castle nut to specification and install cotter pin. If hole in link rod does not align with nearest notch in castle nut, back nut off slightly until it aligns and install cotter pin.

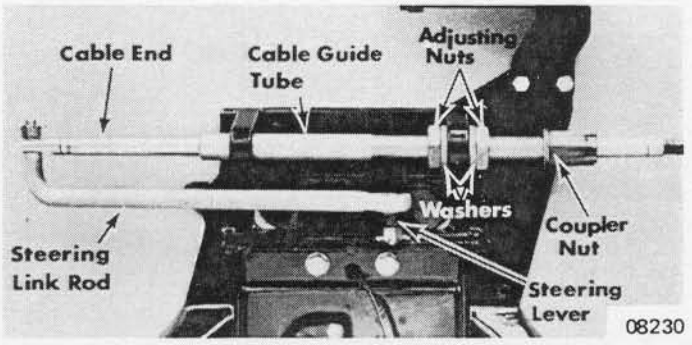


Figure 10. Attaching Steering Cable to Transom Plate from Left

2. Lubricate inside of cable guide tube with Multipurpose Lubricant (C-92-63250).
3. Insert cable end thru guide tube and thread coupler nut on tube and tighten securely. (Figure 9 or 10)
4. Install locking sleeve on coupler nut and secure with cotter pin. (Figure 13)
5. Attach steering link rod to cable end with flat washer and castle nut. (Figure 12) Torque castle nut to specification, back off nut ¼-turn and install cotter pin.
6. If it is necessary to adjust steering after engine and drive unit are installed, see "Adjusting Ride-Guide Steering" (following).

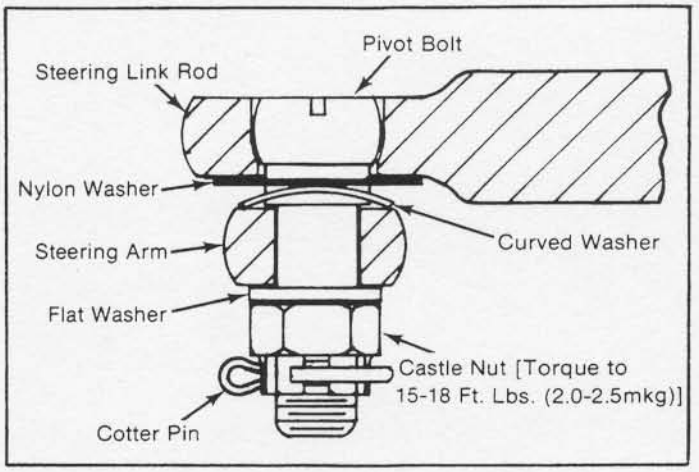


Figure 11. Connecting Steering Link Rod to Steering Lever

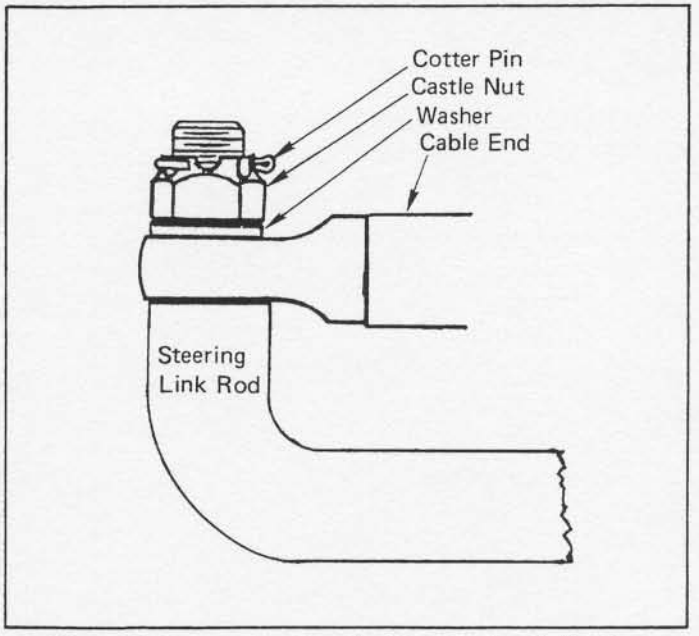


Figure 12. Connecting Steering Link Rod to Cable End

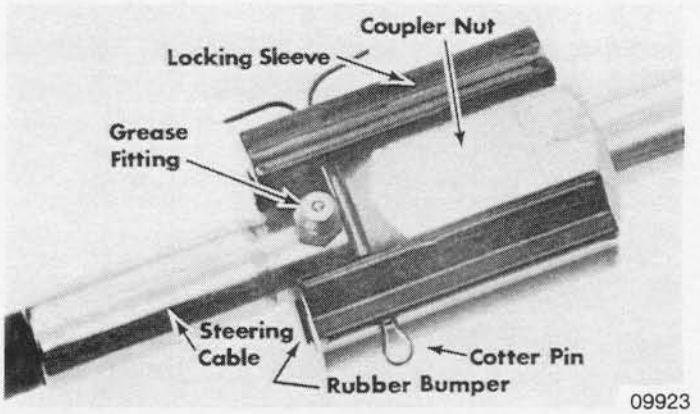


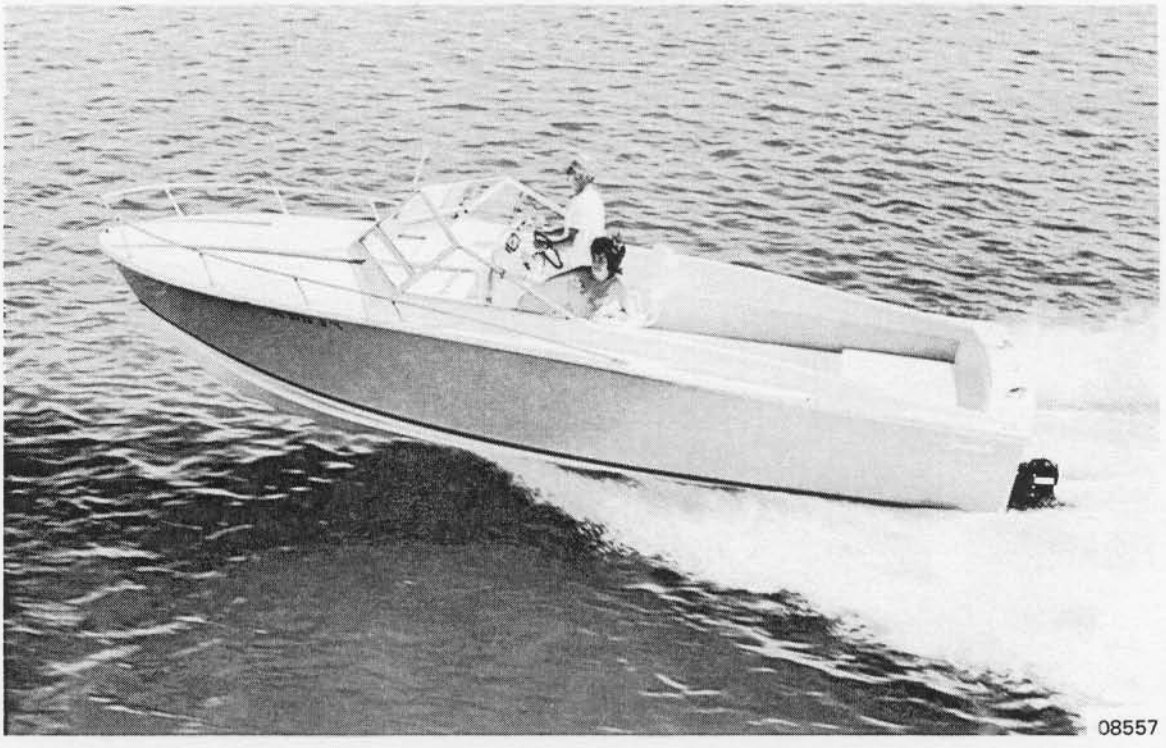
Figure 13. Locking Sleeve Installed on Coupler Nut

ADJUSTING RIDE-GUIDE STEERING

Turn steering wheel to full left and right. Drive unit should traverse fully in both directions. If unit turns further in one direction than other, loosen adjusting nuts and move cable guide tube left or right to allow full traverse. Torque adjusting nuts to 35 to 40 ft. lbs. (4.84 to 5.53mkg). (Figures 9 and 10)

SECTION 2 - REMOVAL, INSTALLATION and ALIGNMENT

PART C - II-TR and II-TRS STERN DRIVE



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MERCURY MARINE®

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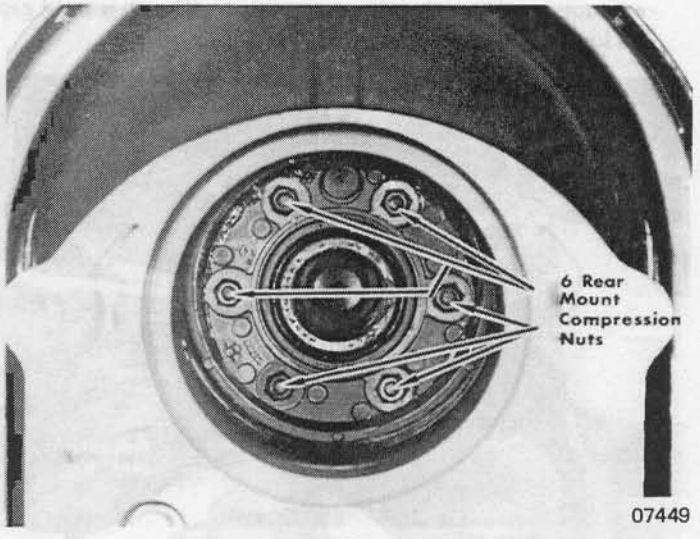
MERCRUISER II-TR and II-TRS ENGINE REMOVAL

IMPORTANT: Stern drive unit must be removed prior to engine removal. Refer to "Stern Drive Removal" (use "Index").

1. Loosen 6 transmission output housing rear mount bolts. (Figure 1)



2. Disconnect battery cables from battery and remove instrument harness connector plug from engine harness receptacle.
3. Disconnect fuel line and throttle cables from engine.
4. Remove electric shift wiring harness from terminal block (located on transmission).
5. Remove trim pump wires from engine.
6. Disconnect Power Steering hoses from steering valve assembly (on engines so equipped) and remove Power Trim hoses from reverse lock. Cap hydraulic hoses and plug their connecting passages.
7. Disconnect water inlet hose and exhaust elbows.
8. Remove vacuum hose from intake manifold.
9. Disconnect any accessories that are connected to engine.

CAUTION: DO NOT lift engine until rear mount is disengaged from gimbal housing, as explained in Steps 10 and 11.

10. Support engine with a suitable sling thru lifting eyes on engine and remove engine front mounting bolts.
11. Pull engine forward to disengage rear engine mount from gimbal housing and carefully remove engine.

Figure 1. Transmission Output Housing Rear Mount Nuts

ENGINE INSTALLATION and ALIGNMENT

IMPORTANT: Prior to installing engine, transom plates must be installed as outlined in "Stern Drive Installation".

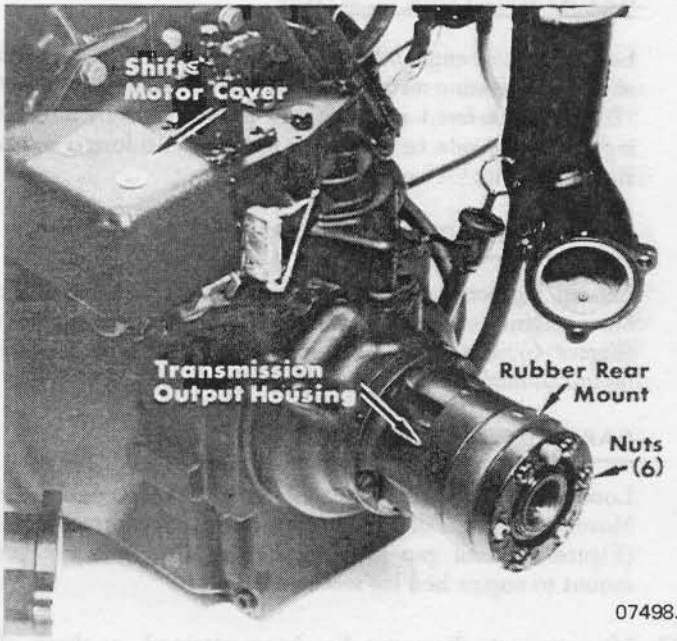


Figure 2. Transmission Output Housing and Rubber Mount

1. Coat rubber rear mount (Figure 2) and gimbal housing opening (Figure 3) with Multipurpose Lubricant (C-92-63250).
2. Lift engine with an overhead hoist, using a suitable sling and lifting eyes on engine.

IMPORTANT: Make sure that 6 nuts on transmission output housing are loose before installing. (Figure 2)

3. Position engine ahead of inner transom plate so that transmission output housing (Figure 2) is in line with large opening in inner transom plate. (Figure 3)

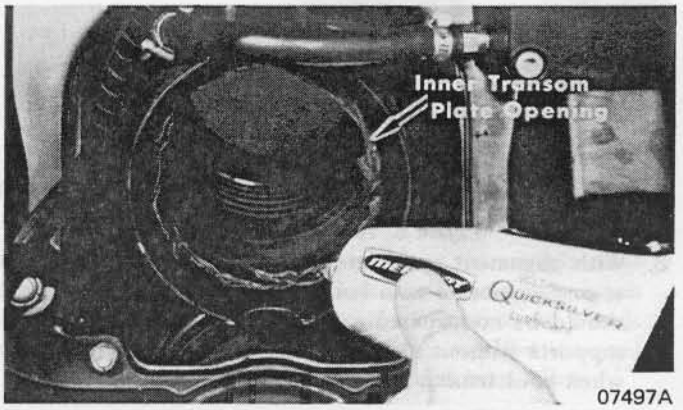


Figure 3. Inner Transom Plate Opening

4. Move engine toward inner transom plate and, at the same time, guide transmission output housing into gimbal housing opening until output housing bottoms-out on shoulder in gimbal housing. Be careful that transmission output housing and rubber mount do not become damaged.

CAUTION: Transmission output housing MUST BOTTOM-OUT on SHOULDER in gimbal housing or exhaust elbow misalignment will result, with subsequent damage to exhaust system.

5. Relieve hoist tension, as required, to allow transmission output housing to seat in gimbal housing.

IMPORTANT: Do not relieve hoist tension entirely at this time, as transmission and output housing may be damaged.

6. Position alignment tool plate on shaft, as shown in Figure 4. Thread Extension (C-91-66695A1) onto Alignment Shaft (C-91-57797A3), insert end of alignment tool into opening in bell housing and into transmission output housing. (Figure 4) Insert shaft until it bottoms-out in transmission output housing.

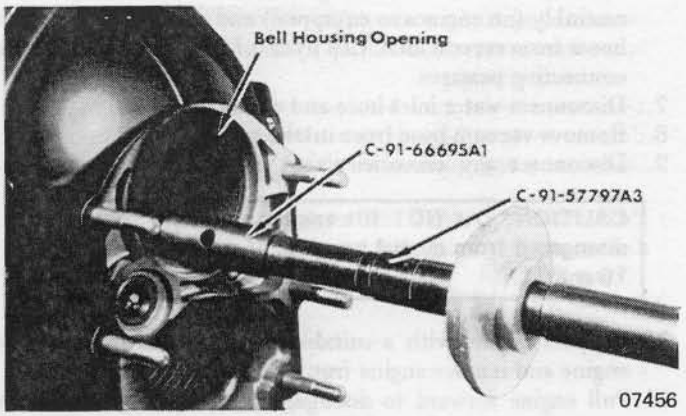


Figure 4. Alignment Tool Location

7. Slide plate toward bell housing. Raise or lower front of engine with hoist to allow shoulder on plate to enter bell housing opening. (Figure 5)

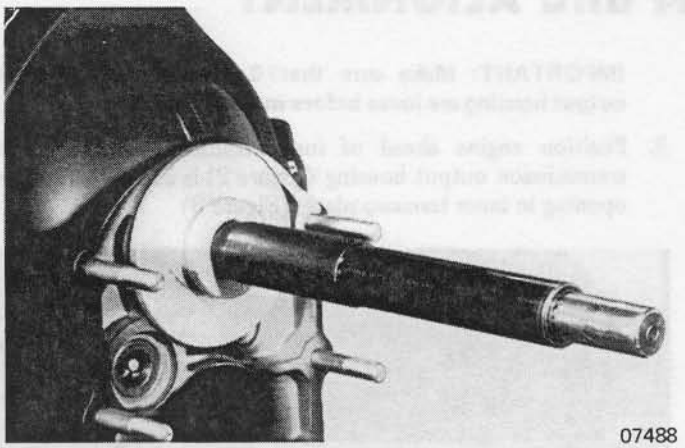


Figure 5. Tool Plate Installed

8. With alignment tool plate positioned in bell housing and engine supported with hoist, front engine mount supports should be constructed so that mounts will rest on top of supports without disturbing alignment tool plate position when hoist tension is relieved.

IMPORTANT: Engine alignment should be near to correct before front engine mounts are fastened to engine bed. Only small adjustment should be necessary in following procedure.

9. Relieve hoist tension entirely and fasten front mounts (with slotted mounting hole toward front of engine) to engine bed. Use 3/8" (9.5mm) diameter lag bolts of sufficient length.

CAUTION: Steering link rod must be disconnected before proceeding with engine alignment.

10. Push alignment shaft and plate toward engine and, while holding plate against bell housing, check for gap between plate and rear surface of bell housing at 12, 3, 6 and 9 o'clock positions. Engine alignment is correct when there is no gap at any point. If gap exists, proceed as follows:

GAP AT 12 O'CLOCK POSITION

Raise front of engine. Loosen locking nuts "A" (Figure 6) and turn adjusting nuts "B" counterclockwise. Turn adjusting nuts "B" (on both front mounts) an equal amount by alternating from one side to the other until gap no longer exists. Retighten nuts "A" securely.

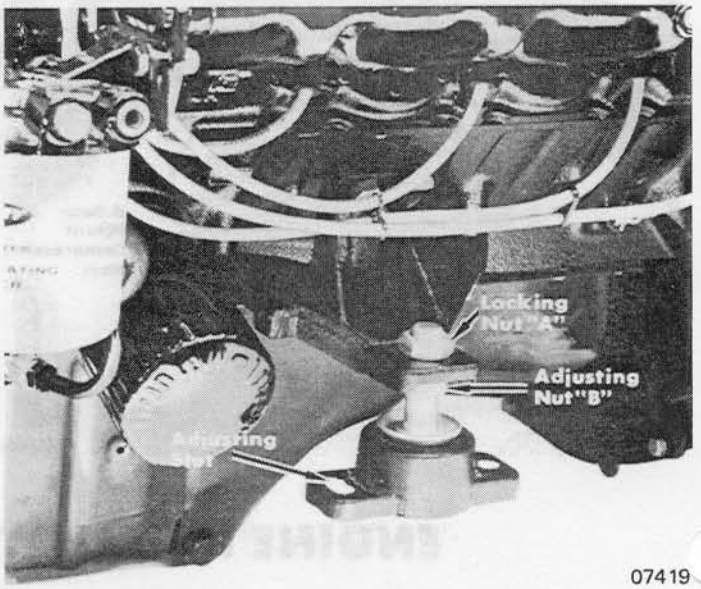


Figure 6. Front Engine Mount Adjustments

GAP AT 6 O'CLOCK POSITION

Lower front of engine. Loosen locking nuts "A" (Figure 6) and turn adjusting nuts "B" clockwise. Turn adjusting nuts "B" (on both front mounts) an equal amount by alternating from one side to the other until gap no longer exists. Retighten nuts "A" securely.

GAP AT 3 O'CLOCK POSITION

Loosen lag screws which attach mounts to engine bed. Move engine to the right (starboard), using adjustment slot (Figure 6), until gap no longer exists. Retighten engine mount to engine bed lag screws securely.

GAP AT 9 O'CLOCK POSITION

Loosen lag screws which attach mounts to engine bed. Move engine to the left (port), using adjustment slot, (Figure 6) until gap no longer exists. Retighten engine mount to engine bed lag screws securely.

11. After correct alignment has been attained, re-check all mount fasteners to be sure that they are tight.
12. Loosen 2 bellows clamps on exhaust manifold elbows (both sides).
13. Connect exhaust elbows to transom plate as shown in Figure 8.
14. Torque exhaust elbow to transom plate screws to specifications.

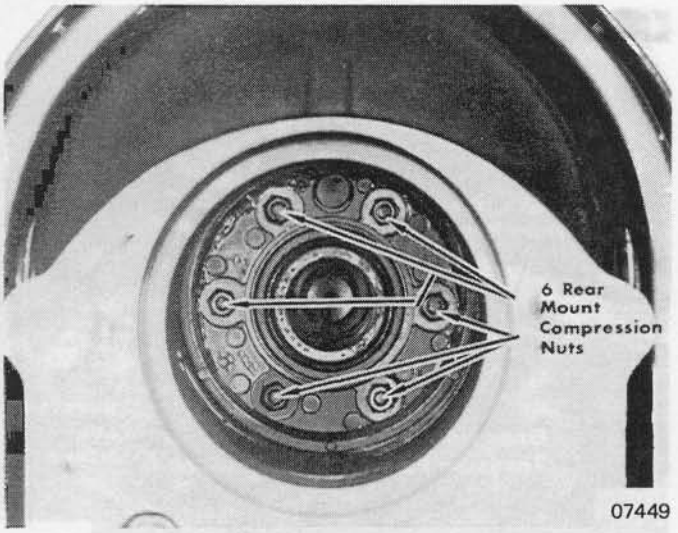


Figure 7. Coupling Nut Location

15. Retighten 2 bellows clamps on exhaust manifold elbows (both sides).
16. Exhaust elbow alignment MUST BE WITHIN ¼" (6.35mm) in any direction. (Figure 8) If elbows are misaligned, recheck engine alignment and installation specifications.
17. Remove alignment shaft and plate. (Shaft should remove easily.)
18. Torque 6 rear mount compression stud nuts to specifications. (Figure 7)
19. Connect water inlet hose to water pump. Torque hose clamps to specifications.
20. Plug instrument harness connector onto engine harness receptacle.
21. Connect Power Trim wires to engine and battery cables to battery.
22. Connect fuel line.
23. Install throttle cables, shift control wires, Power Steering and Power Trim hoses. Refer to instructions following (see "Index").

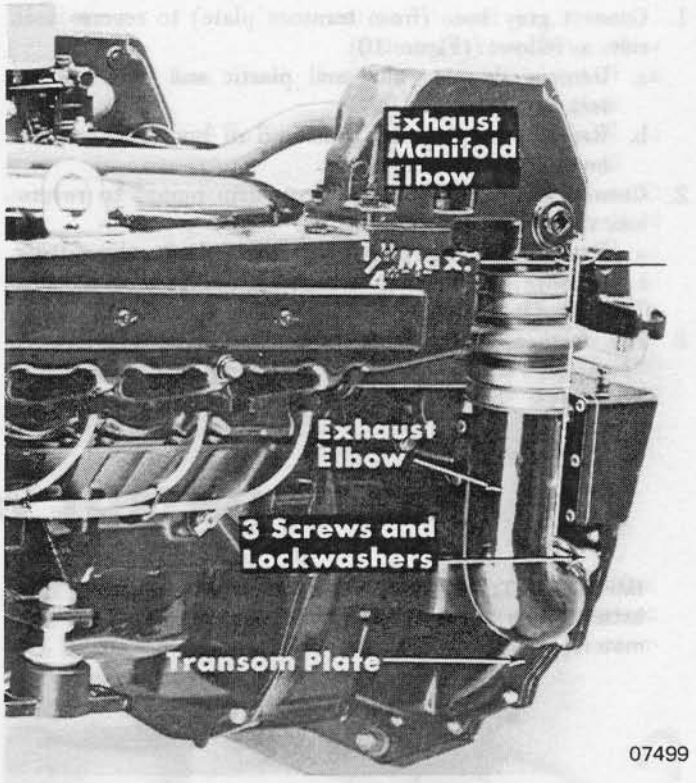


Figure 8. Exhaust System Installation (Left Side Shown)

THROTTLE CABLE INSTALLATION

IMPORTANT: Before proceeding with the following instructions, install throttle cable into remote control. Install control as outlined in instructions which accompany control.

1. Place remote control handle in neutral gear, idle position.
2. Connect cable end guide to throttle lever with screw, bushing, washers and nut. (Figure 9)
3. Grasp cable behind brass barrel and push lightly toward throttle lever. Adjust brass barrel to align with anchor stud and fasten barrel to stud with washers and nut. (Figure 9)

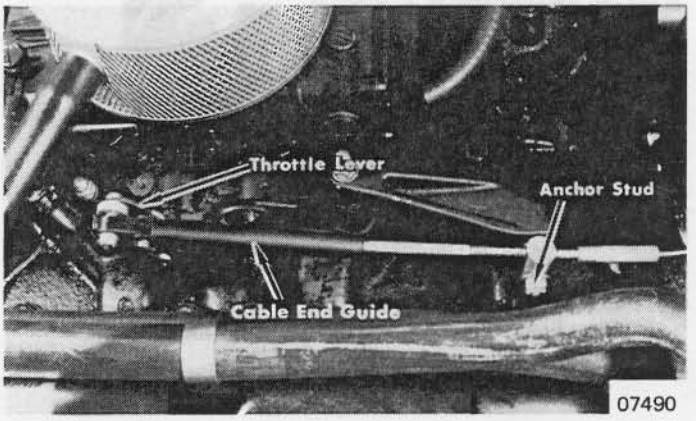


Figure 9. Throttle Cable Installed

POWER TRIM HOSE CONNECTIONS

NOTE: Reverse lock valve and hoses are filled with oil. Make all connections as quickly as possible to prevent oil from draining out.

1. Connect gray hose (from transom plate) to reverse lock valve as follows: (Figure 10)
   a. Remove shipping plug and plastic seal from reverse lock valve fitting.
   b. Remove shipping cap from end of hose and connect hose to reverse lock valve.
2. Connect black plastic hose (from trip pump) to reverse lock valve as follows: (Figure 10)
   a. Remove shipping plug from reverse lock valve fitting.
   b. Remove shipping cap from hose and connect hose to reverse lock valve.
3. For further Power Trim hose connections, refer to "Transom Plate Installation - Installing Hydraulic Pump Hoses" (use "Index").

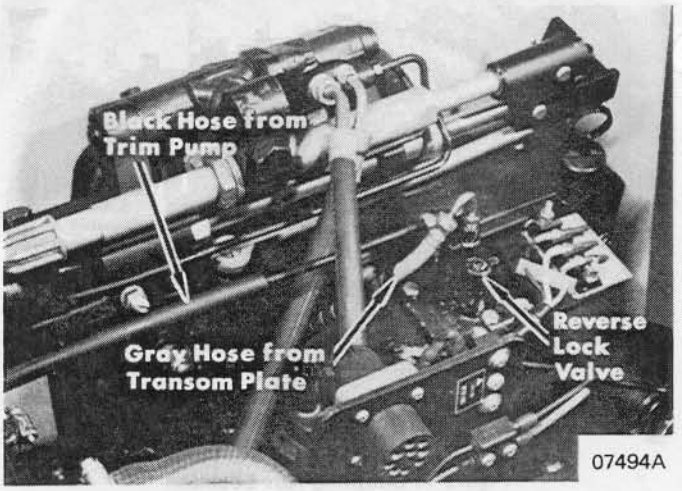


Figure 10. Power Trim Hose Connections - Reverse Lock Valve

SHIFT CONTROL WIRING CONNECTIONS

IMPORTANT: Battery cables must be disconnected from battery prior to connecting shift control wiring to shift motor.

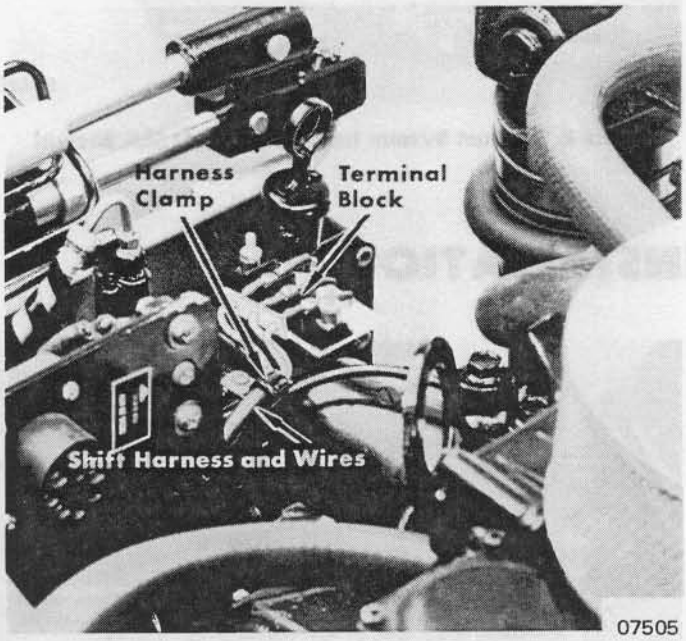


Figure 12. Shift Control Wiring Connections

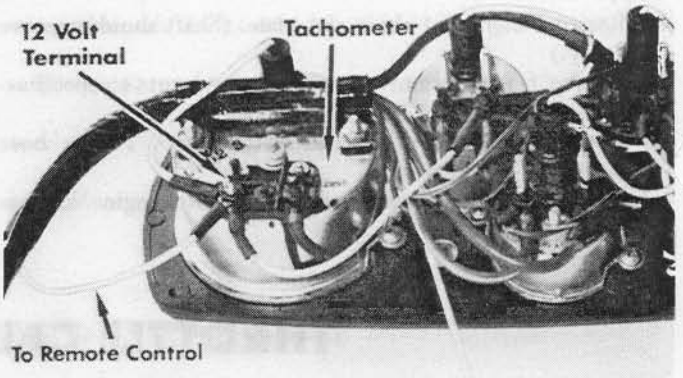


Figure 13. Remote Control Connection

1. Remove shift motor cover. (Figure 1, preceding)
2. Connect ring terminals (located on shift control harness) to terminals on shift motor, matching lead and terminal colors. Fasten harness clamp to shift motor bracket. (Figure 12) Reinstall cover.
3. Connect white wire from remote control to 12-volt terminal (with white wire) on tachometer. (Figure 13) Use nut and insulating cap.

STERN DRIVE UNIT

Removal

1. Disconnect rear end of trim cylinders from drive unit.
2. Support drive unit with suitable sling thru lifting eye on top cover and remove 6 nuts which hold drive unit to bell housing.
3. Carefully remove drive unit.
4. Remove and discard drive shaft housing to bell housing gasket.

Stern Drive Installation

CAUTION: Before installing stern drive unit, engine installation and alignment MUST BE completed and transmission output housing rear mount retaining nuts torqued to specification.

1. Lubricate the following with Multipurpose Lubricant (C-92-63250): Drive shaft housing pilot (Figure 1), "O" ring and oil connectors (Figures 1 and 2). Apply a light coat of lubricant to inside surfaces of bell housing bore and position gasket. (Figure 2)
2. Lubricate U-joint shaft end (internally and externally) with Universal Joint Lubricant (C-92-74058).
3. Place forward anchor pin in gimbal ring. (Figure 2)

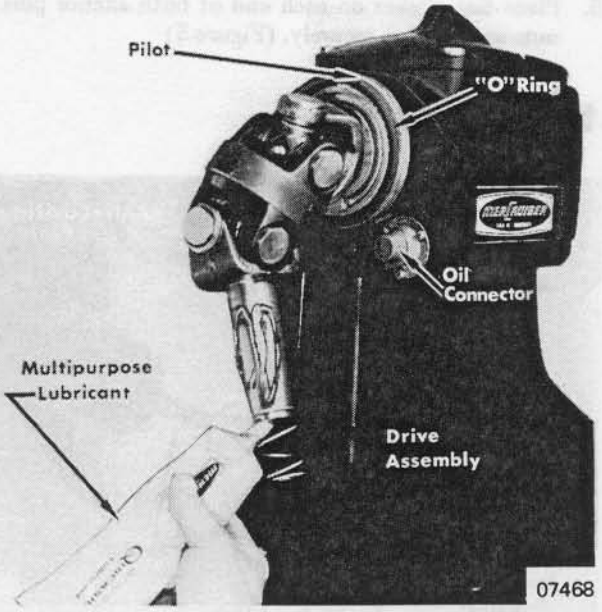


Figure 1. Installation Lubrication Points

NOTE: Use hoisting equipment to hold drive during installation.

4. Insert stern drive unit into bell housing bore (Figure 3) by guiding universal joint shaft thru pilot bearing.

   NOTE: If necessary, support the U-joint front yoke with a length of stiff wire.

5. Push drive shaft housing completely into bell housing (Figure 5) and fasten with 6 elastic stop nuts and flat washers. (Figure 5) Torque to specification.

   NOTE: If universal joint shaft splines do not align with transmission splines, rotate propeller shaft slightly until drive can be pushed into bell housing.

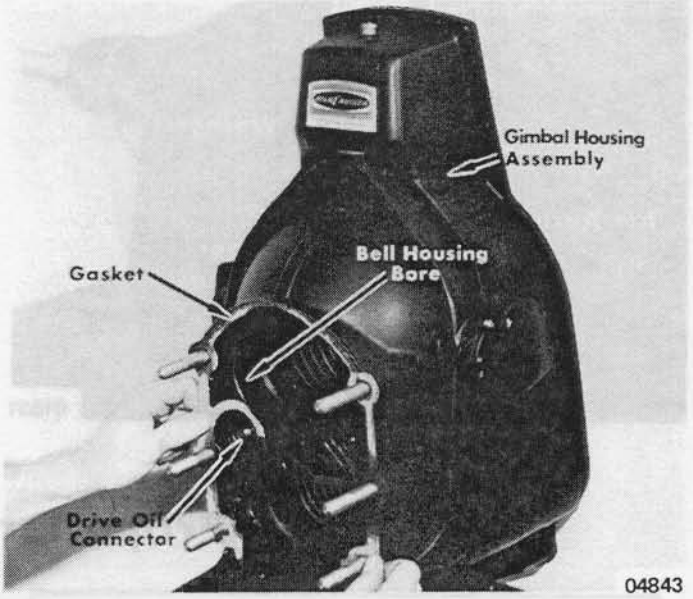


Figure 2. Gasket Position on Bell Housing Studs

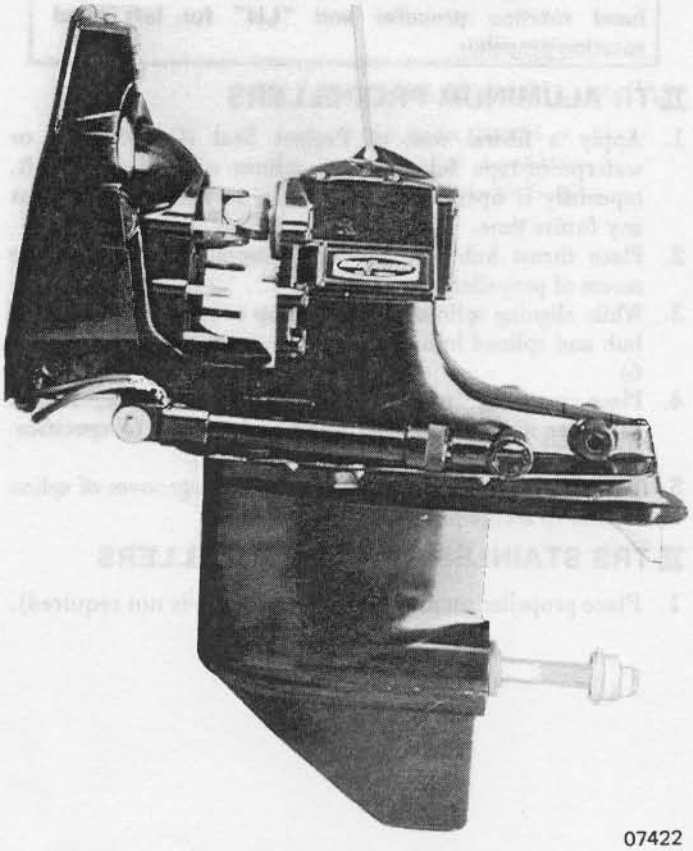


Figure 3. Inserting Drive Unit into Gimbal Housing

Installing Trim Cylinders

1. Place a flat washer, rubber bushing and one spiral spring on each side of forward anchor pin.
2. Install aft anchor pin, large washer, rubber bushing and one spiral spring on each side of aft anchor pin. (Figure 4)
3. Place cylinders on anchor pins.

NOTE: Be sure that one small spiral spring is installed between rubber bushings on each side of both forward and aft anchor pins. (Figure 4) They are required to ground cylinders to drive unit to reduce galvanic corrosion.

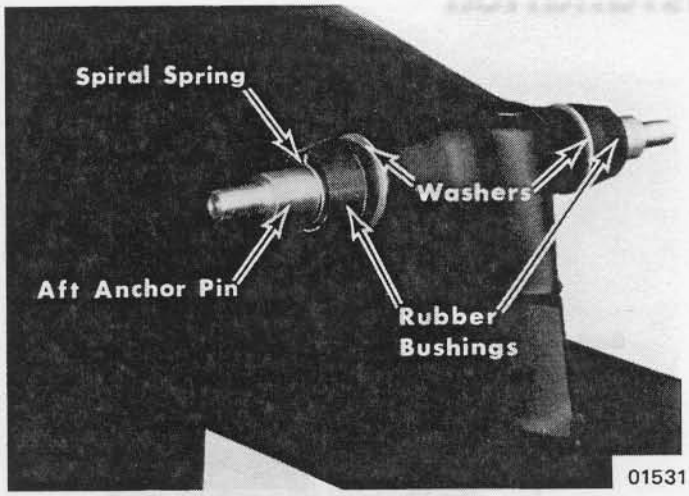


Figure 4. Aft Anchor Pin Installed

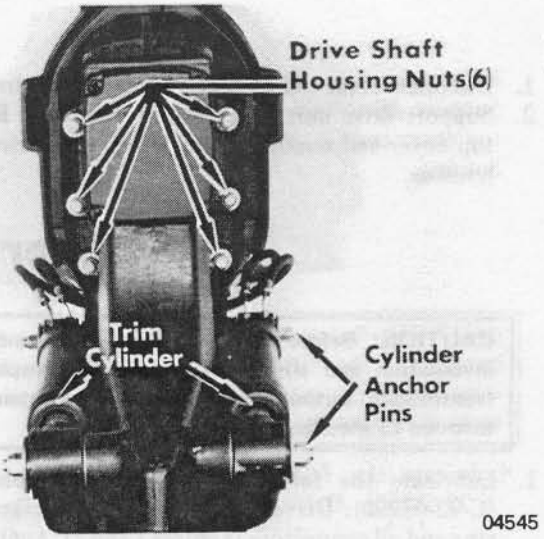


Figure 5. Drive and Trim Cylinders Installed

4. Place rubber bushings in forward and aft end of each cylinder.
5. Place flat washer on each end of both anchor pins. Install nuts and tighten securely. (Figure 5)

Propeller Installation

CAUTION: Propeller MUST BE matched to stern drive rotation. Propeller shaft end is marked "RH" for right hand rotation propeller and "LH" for left hand rotation propeller.

II-TR ALUMINUM PROPELLERS

1. Apply a liberal coat of Perfect Seal (C-92-34227) or waterproof-type lubricant on splines of propeller shaft, especially if operated in salt water, to aid in removing at any future time.
2. Place thrust hub into propeller assembly (shoulder into recess of propeller).
3. While aligning splines, place jet-prop propeller (with thrust hub and splined hub assembly) on propeller shaft. (Figure 6)
4. Place propeller nut in recess of tab washer, thread propeller nut on propeller shaft and torque to specification.
5. Bend 3 of the tabs of tab washer down in grooves of spline washer to secure propeller nut.

II-TRS STAINLESS STEEL PROPELLERS

1. Place propeller on prop shaft (thrust hub is not required).

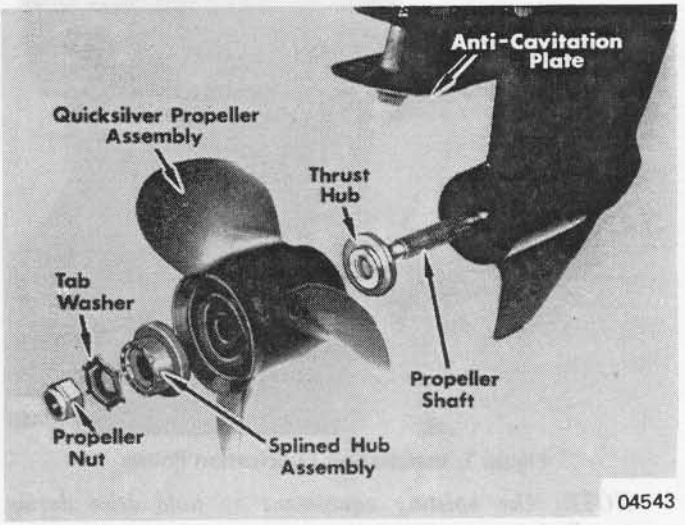


Figure 6. Installing and Removing Propeller

2. In order, place splined washer (with bevel toward propeller), flat washer and propeller nut on prop shaft and tighten securely.

TRANSOM PLATE ASSEMBLY

Removal

IMPORTANT: Drive unit and engine must be removed prior to transom plate assembly removal. Refer to "Drive Unit Removal" and "Engine Removal" (use "Index").

1. Remove steering link rod. (Figure 1)
2. Disconnect and remove steering cable from tube. (Fig. 1)
3. Remove (black) "up" hydraulic hose from trim pump, cap hose and plug hose connections.
4. Disconnect tilt limit switch from trim wiring harness.
5. Disconnect drive unit lubricant oil hose from lubricant reservoir. Plug hose with wooden plug and reinstall hose clamp. Also plug hose fitting in reservoir.
6. Remove nuts which hold inner and outer transom plates together, then remove inner transom plate and outer transom plate in that order.

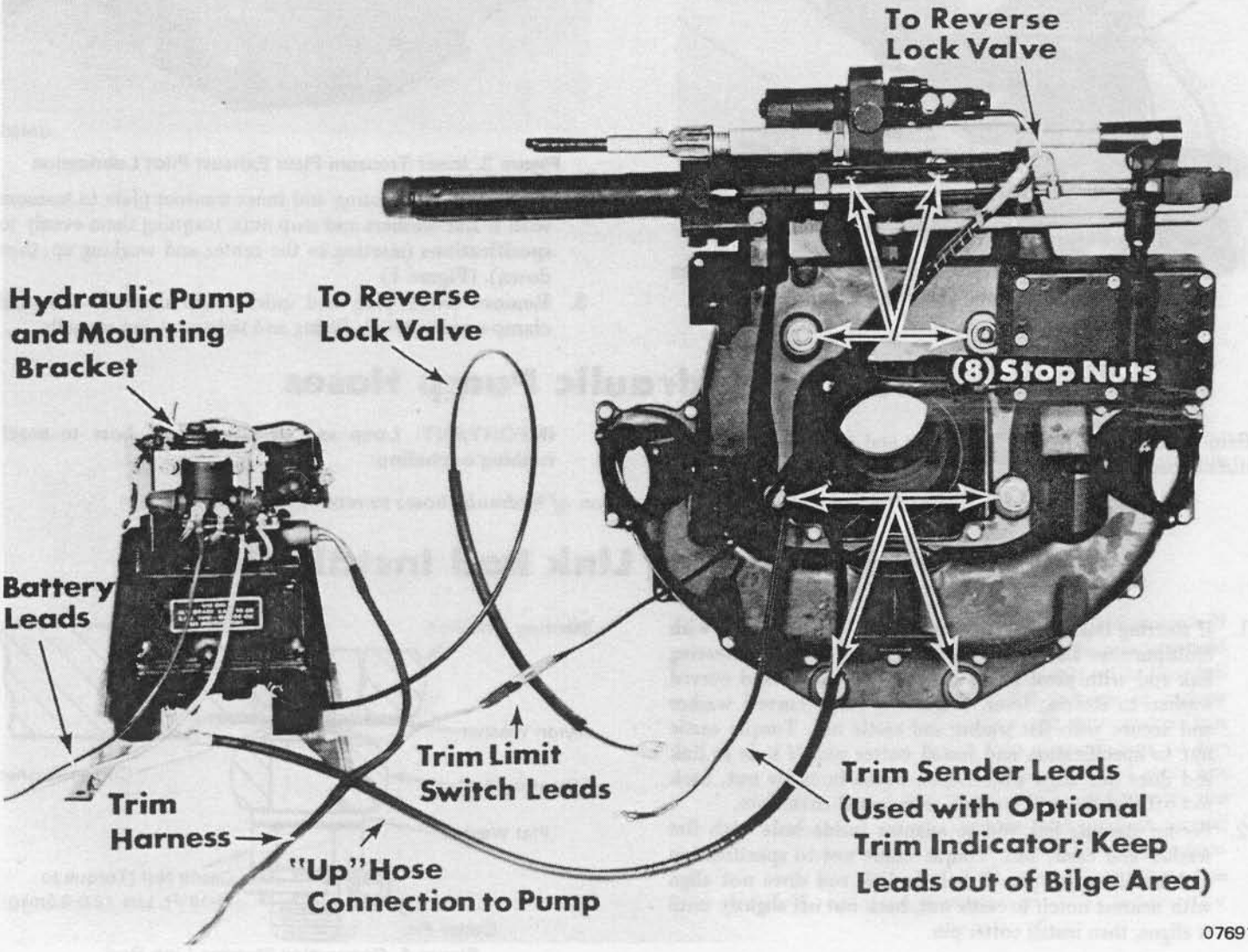


Figure 1. Transom Plate Installation

Transom Plate Installation

1. Lubricate exhaust tube "O" ring in gimbal housing assembly (Figure 2) and inner transom plate exhaust pilot. (Figure 3) Position them in transom holes, inserting switch leads, hydraulic hoses, unit oil hose and steering link rod thru openings in transom. Hold gimbal housing in position.

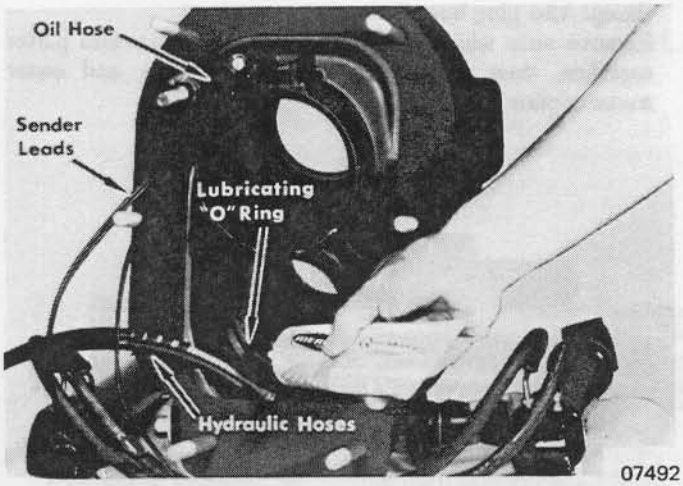


Figure 2. Exhaust Tube "O" Ring Lubrication

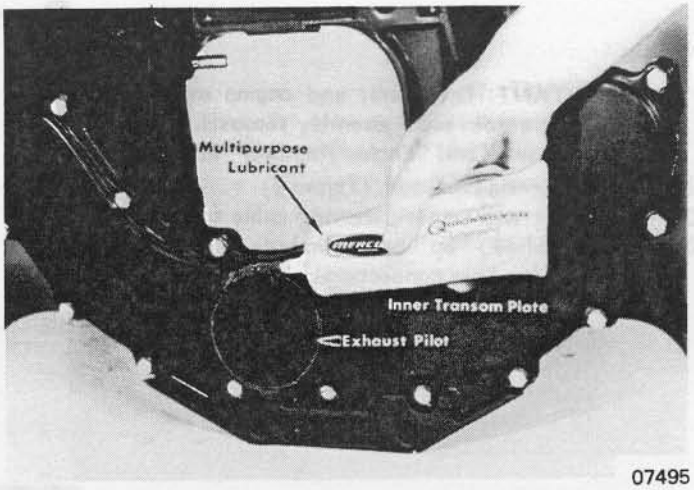


Figure 3. Inner Transom Plate Exhaust Pilot Lubrication

2. Fasten gimbal housing and inner transom plate to transom with 8 flat washers and stop nuts, torquing them evenly to specifications (starting in the center and working up, then down). (Figure 1)
3. Remove wood plug and quickly slip drive oil hose and clamp over reservoir fitting and tighten clamp securely.

Installing Hydraulic Pump Hoses

Remove cap from (black) "up" hose and plug from pump to install hose. (Figure 1)

IMPORTANT: Loop and tie down loose hose to avoid rubbing or chafing.

NOTE: Refer to engine installation for connection of hydraulic hoses to reverse lock valve.

Ride-Guide Steering Link Rod Installation

1. If steering link rod was removed, lubricate pivot area with Multipurpose Lubricant (92-63250) and connect steering link rod with pivot screw in rod, flat washer and curved washer to steering lever. (Figure 4) Align curved washer and secure with flat washer and castle nut. Torque castle nut to specification and install cotter pin. If hole in link rod does not align with nearest notch in castle nut, back nut off slightly until it aligns, then install cotter pin.
2. Secure steering link rod to adaptor inside hole with flat washer and castle nut. Torque castle nut to specification and install cotter pin. If hole in link rod does not align with nearest notch in castle nut, back nut off slightly until it aligns, then install cotter pin.

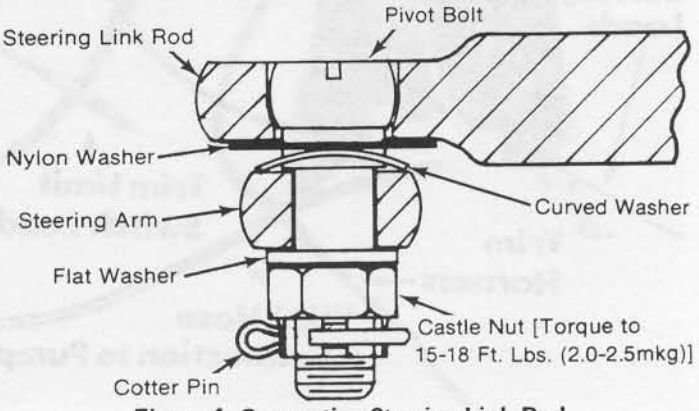


Figure 4. Connecting Steering Link Rod

Mounting Steering Unit to Transom Plate

1. Apply thin coat of Quicksilver Multipurpose Lubricant (C-92-63250) to attaching and mounting parts of Power Steering unit during assembly.
2. Insert mounting tube thru first transom boss. Thread jam nut fully onto tube and tighten securely, then insert mounting tube thru second boss. (Figure 5)

NOTE: Left side Power Steering unit is installed on opposite side in same manner.

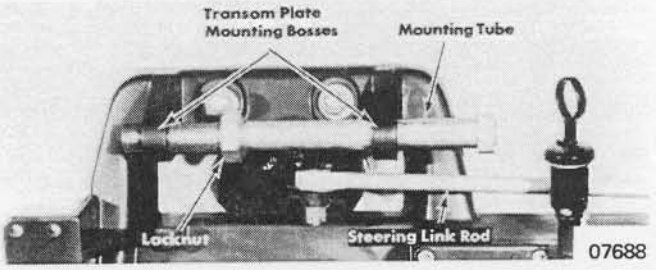


Figure 5. Installing Mounting Tube - Right Side

3. Lubricate Power Steering unit extension rod with Multipurpose Lubricant and insert rod thru mounting tube. (Figure 6) Thread mounting tube into Power Steering unit until jam nut bottoms against transom boss. (Figure 7) Using a 1⅛" deep well socket, torque tube to 50 to 60 ft. lbs. (6.9 to 8.3mkg), using nut on end of mounting tube.

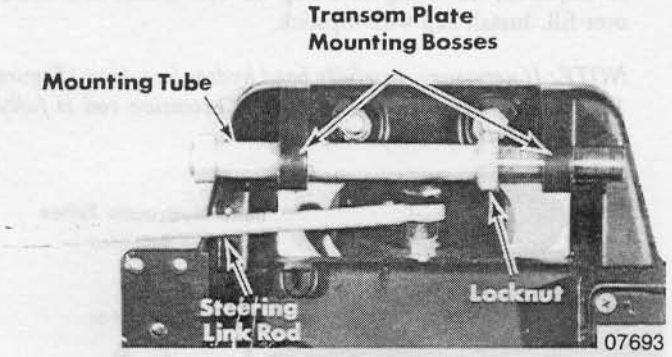


Figure 6. Installing Mounting Tube - Left Side

4. Turn adjusting screw in firmly against transom and secure with locknut. (Figure 8) Place guide slide over cable guide tube.
5. Attach cable end adaptor to extension rod with clevis pin, as shown in Figure 9. Secure clevis pin with cotter pin.
6. Install steering link rod to adaptor and secure with washer and castle nut. Torque nut to 20 to 25 in. lbs. (23 to 28 kg-cm), then secure castle nut with cotter pin (bend ears around nut). (Figure 9) (If necessary, back off nut until cotter pin can be installed.)
7. Lubricate cable guide tube with Multipurpose Lubricant (C-92-63250) and insert cable thru cable guide tube. Thread coupler nut onto guide tube and torque to 35 to 40 ft. lbs. (4.8 to 5.5mkg). Install locking sleeve on coupler nut and secure with cotter pin. (Figure 10)
8. Attach cable to cable end adaptor with clevis pin. (Figure 9) Secure clevis pin with cotter pin.

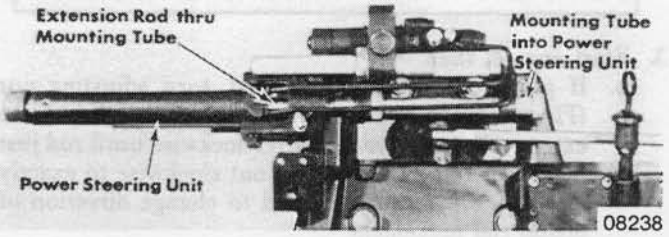


Figure 7. Mounting Power Steering Unit

IMPORTANT: This Power Steering Unit is shipped with the steering cable guide tube preset (to dimension shown in Figure 8) for cables with end dimensions called for by the BIA Certification Handbook. Therefore, only cables, which comply with the BIA Certification Handbook end dimensions, should be installed on this unit. If cables with improper dimensions are installed, severe damage to the drive unit and/or steering system may result. DO NOT attempt to adjust steering cable guide tube, as guide tube adjusting nut and sleeve have been torqued with Loctite applied at the factory, and an attempt to loosen adjusting nut or sleeve may result in damage to tube.

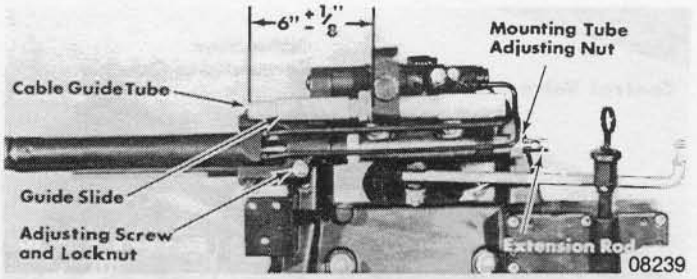


Figure 8. Power Steering Unit Secured

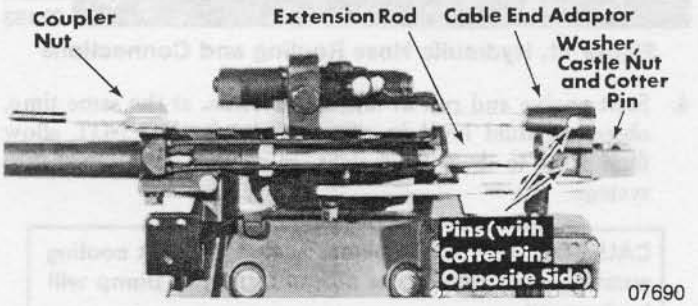


Figure 9. Cable End Adaptor and Link Rod Attached to Dual Station Cable End Adaptor

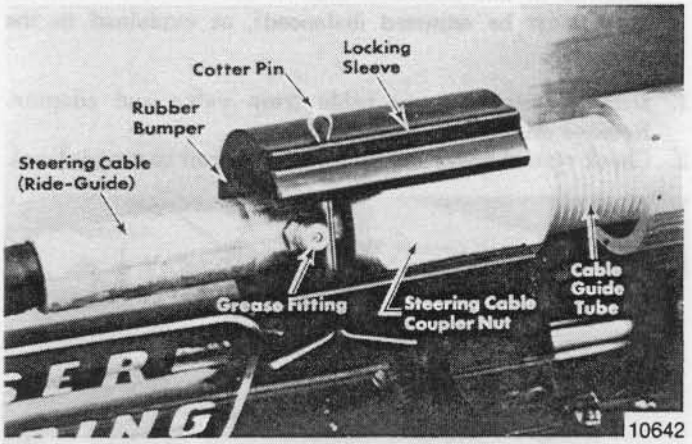


Figure 10. Locking Sleeve Installed

Connecting Hydraulic Hoses to Power Steering Unit and Filling System with Fluid

1. Route hoses, as shown in Figure 11, to Power Steering control valve.
2. Remove both plugs from valve and remove connector from both hose fittings, then quickly make connections to prevent loss of oil. (Figure 11)
3. Remove cap from pump and add type "A" automatic transmission fluid, as required, to bring level up to "Full" mark on dipstick which is attached to fill cap. DO NOT install cap at this time.

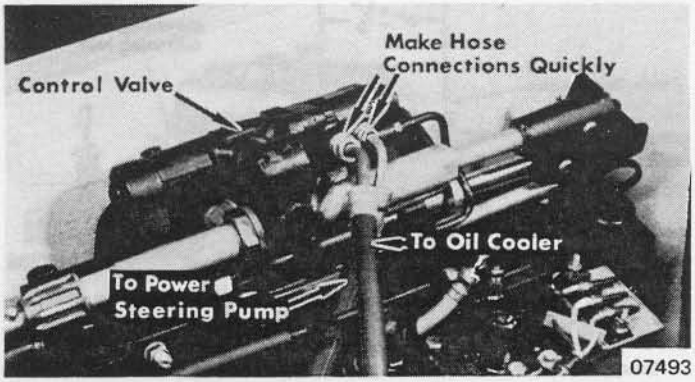


Figure 11. Hydraulic Hose Routing and Connections

4. Start engine and run at idle speed while, at the same time, observing fluid level in pump reservoir. DO NOT allow fluid level to drop from sight, as air will be induced into system.

CAUTION: DO NOT operate engine without cooling water flowing thru water pickup pump, or pump will be damaged.

5. With assistance of another person, turn steering wheel back-and-forth to end of its travel in each direction (engine running at idle speed) and, at the same time, observe fluid level in pump reservoir. Add fluid, as required, to keep level visible in reservoir. DO NOT allow level to drop from sight, as air will be induced into system. Continue turning wheel back-and-forth until fluid level remains constant. If fluid is extremely foamy, stop engine and allow air to disperse. Then repeat above procedure until level remains constant.
6. Stop engine and check fluid level with dipstick. Add fluid, as required, to bring level up to full mark. DO NOT over-fill. Install cap with dipstick.

NOTE: If necessary, carefully bend hydraulic tubing (Figure 12) to clear cable end adaptor when extension rod is fully retracted (full left turn).

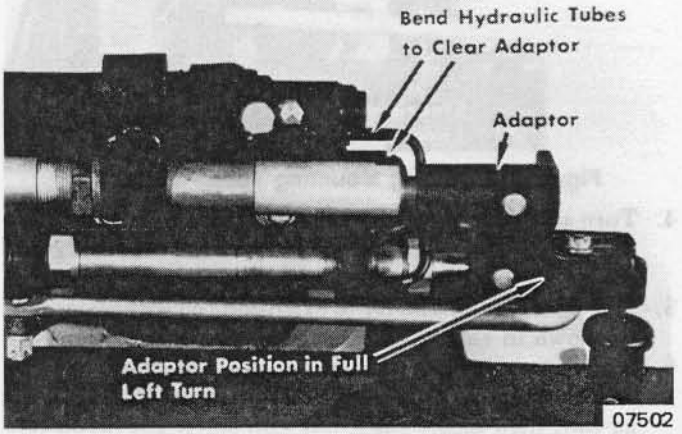


Figure 12. Hydraulic Tubing Clearance

Valve Balancing (Complete Only If Necessary)

IMPORTANT: After installation, if more steering effort is required in one direction than in the other, the control valve must be adjsuted (balanced), as explained in the following.

1. Detach steering input cable from valve and adaptor. Remove dust cover. (Figure 13)
2. Check system hoses and fill pump reservoir to proper level.

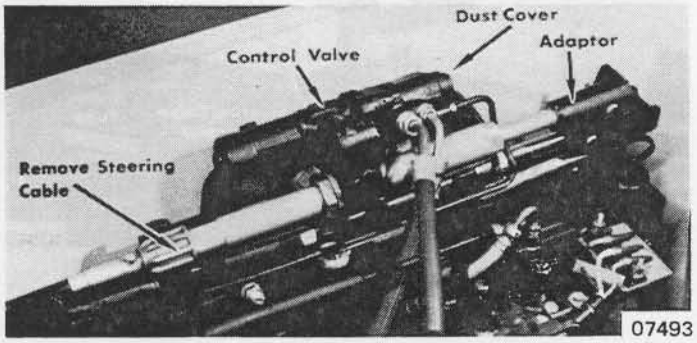


Figure 13. Preparation for Valve Balancing

Figure 14. Adjusting Nut Location

CAUTION: Use care when turning adjusting nut. Use long extension shaft(s) on socket when turning adjusting nut and BE CAREFUL not to place hands in a position where they could be injured by cable adaptor movement.

3. Start engine, then —
   a. If piston rod remains retracted, turn adjusting nut (Figure 14) clockwise until piston rod begins to extend, then turn nut counterclockwise until rod just begins to retract. Now turn nut clockwise to exactly one-half the rotation needed to change direction of piston rod movement.
   b. If piston rod extends, turn adjusting nut (Figure 14) counterclockwise until piston rod begins to retract, then turn nut clockwise until rod just begins to extend. Now turn nut counterclockwise to exactly one-half the rotation needed to change directon of piston and movement.

NOTE: DO NOT move adjusting nut more than necessary, so that its friction-locking quality is retained.

4. When valve is balanced, valve and cylinder assembly may be moved in-or-out manually.
5. Turn off engine. Reinstall input cable and complete reinstallation.
6. Restart engine. If cable end adaptor does not move in either direction, valve adjustment is correct. If not, rebalance valve.
7. Stop engine after valve is adjusted. Place Multipurpose Lubricant (C-92-63250) on end of valve and install dust cap and reconnect steering input cable.

SECTION 2 - REMOVAL, INSTALLATION and ALIGNMENT

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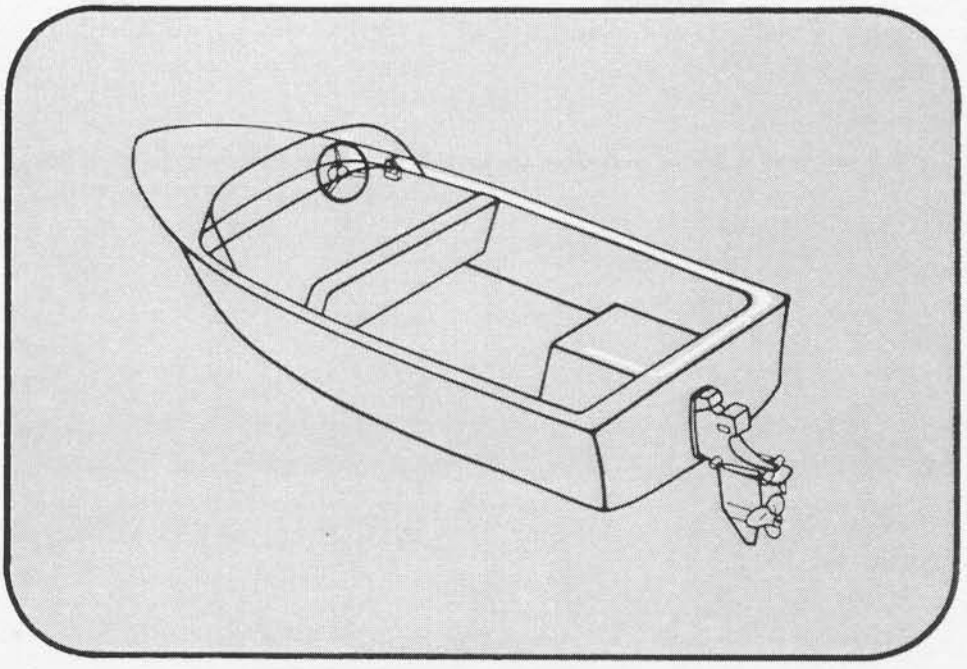
PART D - GENERAL INSTALLATION



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MEASURING BOAT for REMOTE CONTROL CABLE LENGTH

SHIFT CABLE MEASUREMENT

1. Add boat measurements A to B and B to C in inches (or centimeters). (Figure 1)
2. Divide by 12. This is cable length in feet.

Calculated 11 ft. 6 in. - use 11 ft. cable.
Calculated 11 ft. 7 in. - use 12 ft. cable.

Metric
1 ft. = 30.5cm
1 in. = 2.54cm

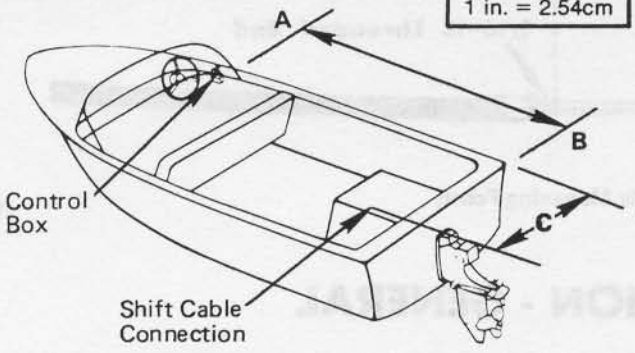


Figure 1. Remote Control Shift Cable Measurement

NOTE: On boats with considerable freeboard drop or unusual routing of cables, it may be necessary to add extra length to cables.

THROTTLE CABLE MEASUREMENT

1. Add boat measurements A to B, B to C and C to D in inches (or centimeters). (Figure 2)
2. Divide by 12. This is cable length in feet.

Calculated 11 ft. 6 in. - use 11 ft. cable.
Calculated 11 ft. 7 in. - use 12 ft. cable.

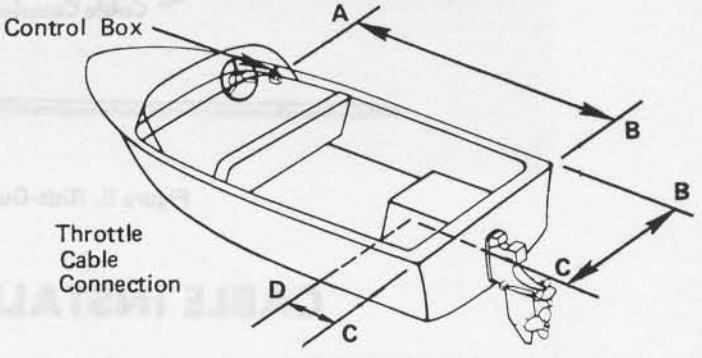


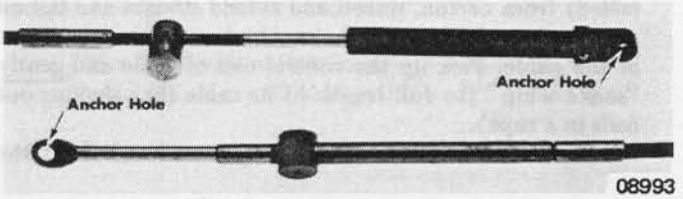
Figure 2. Remote Control Throttle Cable Measurement

NOTE: On boats with considerable freeboard drop or unusual routing of cables, it may be necessary to add extra length to cables.

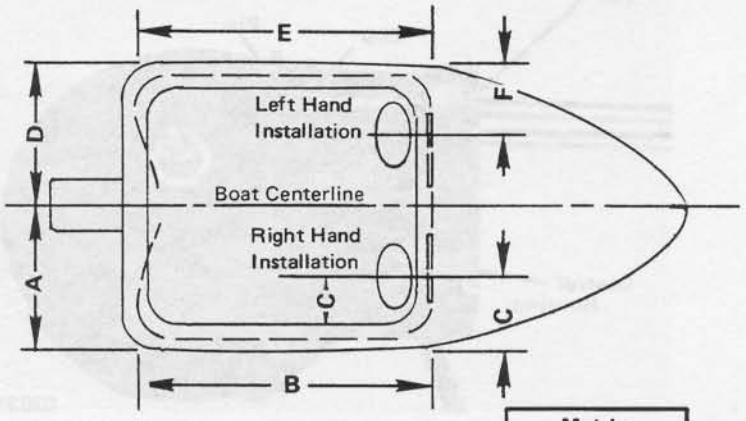
MEASURING REMOTE CONTROL CABLES

Remote control cable is measured from anchor hole to anchor hole. (Figure 3)

Figure 3. Remote Control Cable Measuring Points



MEASURING BOAT for RIDE-GUIDE STEERING CABLE LENGTH



Ride Guide cable can be routed down right or left hand side of boat.

Metric
1 ft. = 30.5cm
1 in. = 2.54cm

Figure 4. Ride-Guide Steering Cable Measurement

1. Measure the routing of the cable (in inches [or centimeters], as shown in Figure 4) from the center of the helm to the center of the engine or drive unit (A-B-C in inches if the steering wheel is located on the right [starboard] side of the boat).
2. Adjust cable length as follows: On all MerCruiser models (except in-line models equipped with power steering) add 6 inches to this dimension. With power steering installed on in-line models, subtract 6 inches from this dimension.

   NOTE: The above dimensions allow for an 8 inch radius at two cable bending points. On boats with larger cable radii, it may be necessary to order a slightly shorter cable length.
3. Divide by 12 inches.
4. This is the cable length in feet for ordering.
   a. Measured 15 ft. -- order 14 ft. 6 in. cable.
   b. Measured 15 ft. 1 in. -- order 15 ft. 6 in. cable.
5. For left hand (port) installation, follow the same measuring procedure, only on the opposite side of boat.

NOTE: On boats with considerable freeboard drop or unusual routing of cables, it may be necessary to add extra length to cables.

RIDE-GUIDE CABLE MEASUREMENTS

Ride-Guide cable is measured from cable fastening nut to 9/16-18 threaded end, as shown in Figure 5.

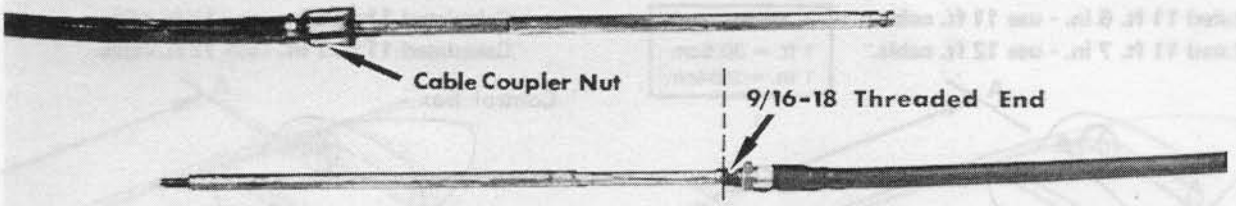


Figure 5. Ride-Guide Cable Measuring Points

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CABLE INSTALLATION - GENERAL

1. Ride-Guide cables MUST BE the correct length, particularly when installed on large boats. Sharp bends on too-short cables result in cable kinks; too-long cables require unnecessary bends and loops; and both place an extra stress on the cables. The proper cable is as short as possible, with the fewest bends and with radii of bends as large as possible.
2. When installing a Ride-Guide cable, remove cable (as coiled) from carton, unroll and extend straight and flat on a clean floor. Make sure that no kinks nor windups occur in the cable. Pick up the control end of cable and gently "snake whip" the full length of its cable (like shaking out coils in a rope).
   Next, check for kinks by running your hand along the entire length of the cable. Straighten any and all kinks or replace if damaged.

CAUTION: Cables are damaged when stepped-on or when placing an external load on the casing. DO NOT place cable where such damage can occur, such as on the assembly floor, boat bottom, etc.

3. Cable must be installed into boat from the rolled-out (straight) condition, as explained in preceding Paragraph 2, and care should be exercised to prevent kinking while pulling through the boat. NEVER install cable directly from carton into boat, as it may cause extra stress on cables.

SHIFT and THROTTLE CABLE REPLACEMENT

REMOTE CONTROLS with CABLE REPLACEMENT COVERS (Figure 1)

CAUTION: "Cable Installation - General", above, MUST BE read and followed before installing remote control cables into boat.

NOTE: It is not necessary to disassemble control housing to install control cables. Cable replacement procedures are identical for port (left) and starboard (right) controls.

1. Remove remote control from its mounted position in boat.
2. Remove cotter pins and covers. (Figure 1)

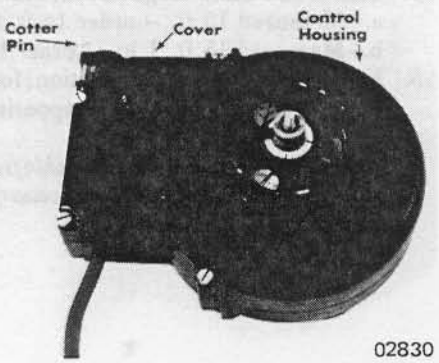

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Figure 1. Typical Cotter Pin and Cover Location

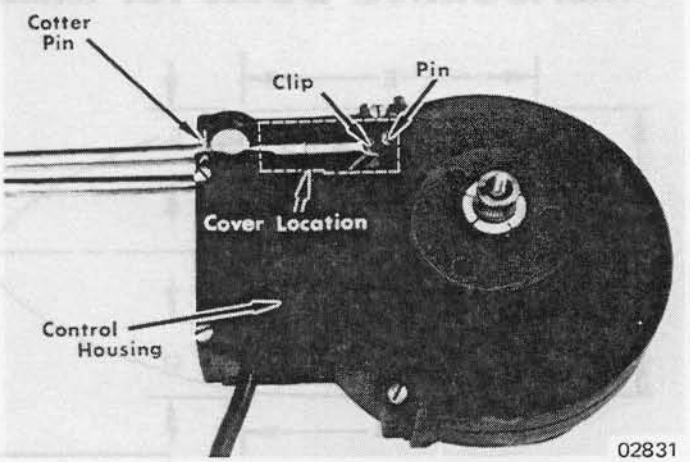

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Figure 2. Control Cables Installed in Typical Control Housing

3. Move control shift handle approximately 45° toward reverse position. This will position shift and throttle levers so that control cables can be removed or installed.

   NOTE: To distinguish between shift and throttle cables (when installed in control) observe metal portion of cable where cable protrudes from control box while moving shift control handle. This portion of control cable will deflect when cables are actuated. The shift cable will deflect first and then throttle cable.

4. Control cables are held in position with pins and hairpin clips. (Figure 2)
5. Replace cable(s) and reinstall covers and cotter pins.
6. Reinstall remote control in boat.

NOTE: For instructions on installing shift cable to transom plate assembly, refer to "Drive Unit Installation" of appropriate drive unit. For instructions on installing throttle cable to engine, refer to "Engine Installation" of appropriate engine.

MERCONTROL B-34744A1 and B-44958A2-A5

CAUTION: "Cable Installation - General", preceding, MUST BE read and followed before installing remote control cables into boat. (See "Index".)

1. Remove remote control from its mounted position in boat.

NOTE: It may be necessary to disconnect neutral start safety switch wires.

2. Remove control shift handle.
3. Remove 4 screws, which hold control housing halves together, and lift left side housing off (housing without neutral warmup lever) to separate halves. (Figure 3)

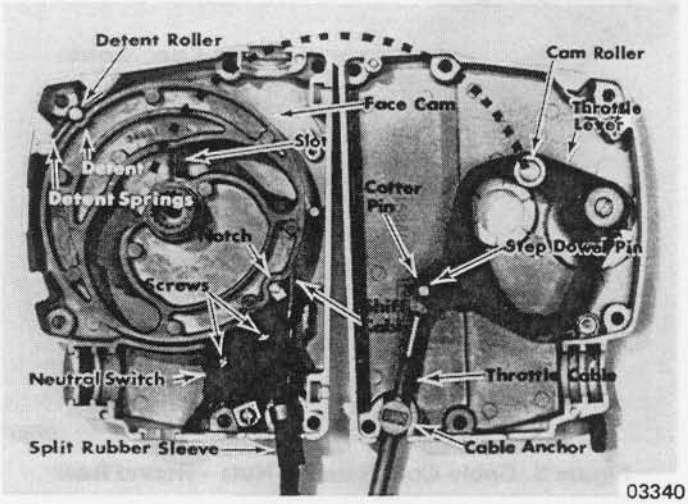


Figure 3. Control Halves

4. Remove detent roller.
5. Replace control cables as follows:

Shift Cable

a. Move neutral safety switch out of position.
b. Lift face cam out of housing.
c. Remove cotter key and pin from shift lever and remove shift cable.
d. Install new shift cable and anchor pin and cotter key.
e. Reposition neutral safety switch and tighten screws securely.
f. Install face cam, aligning tooth and notch as shown in Figure 4.

Throttle Cable

a. Remove cotter key and pin from throttle lever and remove throttle cable.
b. Install new cable and anchor pin and cotter key.

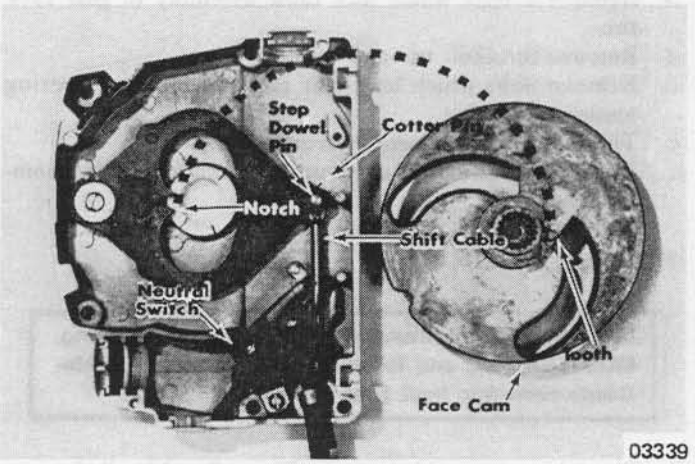


Figure 4. Installing Face Cam

6. Position face cam so that cam detent is aligned with detent springs, then install detent roller. (Figure 3)
7. Position throttle lever so that its cam roller will align with slot in face cam, as indicated in Figure 3.
8. Place halves together. If housing halves do not join, lift and lower neutral warmup lever while holding halves together, to help align cam roller and face cam slot. If halves still fail to join, reposition as shown in Figure 3.
9. Place screws thru housing halves and tighten evenly.
10. Set handle into splined hub on desired side and turn until detent (neutral position) is noted. Reset handle so that it is in vertical position. Install handle screw with lockwasher and tighten securely.

WARNING: Remote control handle retainer screw MUST BE fastened securely. Failure to do so could allow handle to disengage, with subsequent loss of throttle control.

11. Reinstall remote control in boat.

NOTE: For instructions on installing shift cable to transom plate assembly, refer to "Drive Unit Installation" of appropriate drive unit. For instructions on installing throttle cable to engine, refer to "Engine Installation" of appropriate engine.

RIDE-GUIDE STEERING CABLE REPLACEMENT (Standard Ride-Guide)

REMOVAL

1. Remove rubber or plastic cap from end of gear rack assembly.
2. Remove cotter pin and locking cap. (Figure 1 or 2)
3. Remove 2 nuts which lock cable assembly to gear rack tube.
4. Remove thru-bolt nut and washer.
5. Remove bolts which hold gear rack assembly to steering mounting bracket.
6. Thread gear rack assembly from cable.
7. Disconnect cable from drive unit and remove cable assembly from boat.

INSTALLATION

CAUTION: "Cable Installation - General", preceding, MUST BE read and followed before installing Ride-Guide cable into boat. (See "Index".)

1. Thread steering cable jam nut (Figure 8 or 14) all-the-way onto threaded end of steering cable. DO NOT torque "jam" nut at this time.
2. Thread gear rack assembly fully onto steering cable.

CAUTION: DO NOT thread steering cable into gear rack. Rather, turn gear rack onto steering cable so that cable housing will not wind up and cause hard steering.

3. Push transom end of steering cable inward to bottom out inner core cable.
4. Remove and retain cap from end of gear rack assembly (if not previously removed).
5. Clean grease from steering cable threads which are exposed beyond rack gear.
6. Thread cable retainer nut onto cable core (Figure 3 or 4) and tighten nut to 90 in. lbs. (104kg-cm). Install second nut over nut just installed to act as a "jam" nut and torque second nut to 90 in. lbs.
7. Install plastic locking cap over second "jam" nut and secure with cotter pin. Spread ends of cotter pin as shown. (BE SURE that cable core is retained as instructed and as shown in Figure 1 or 2.)
8. Install cap onto end of gear rack.
9. Move transom end of steering cable in-and-out several times to assure that no bind exists in gear rack or steering cable.
10. Center gear rack in pinion gear opening of gear rack assembly. (Figure 5)
11. Lubricate outer surface of pinion gear bushings with

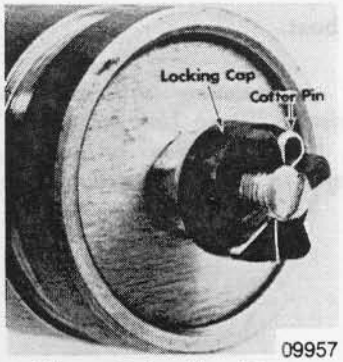


Figure 1. Locking Cap - Round Rack

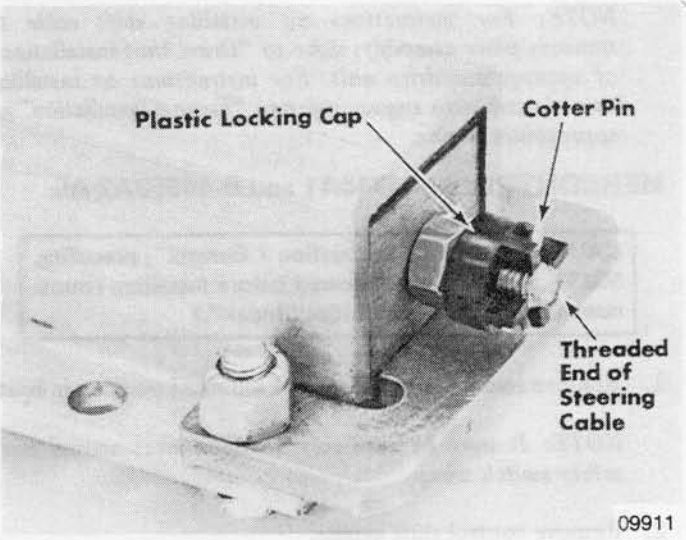


Figure 2. Locking Cap - Square Rack

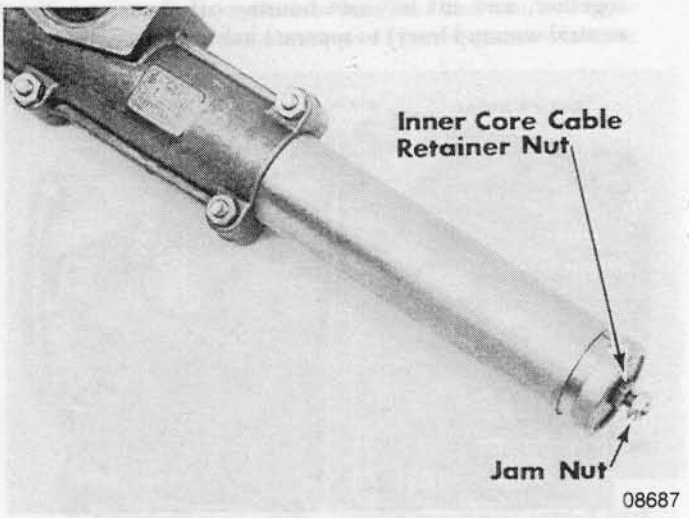


Figure 3. Cable Core Retainer Nuts - Round Rack

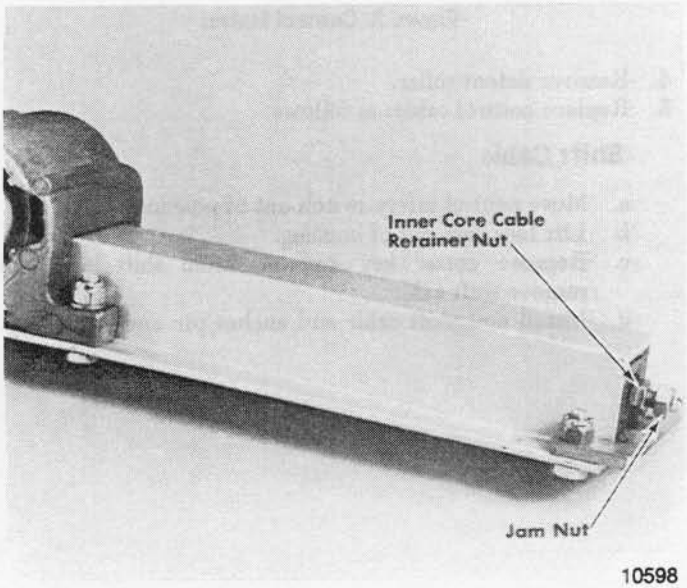


Figure 4. Cable Retainer Nuts - Square Rack

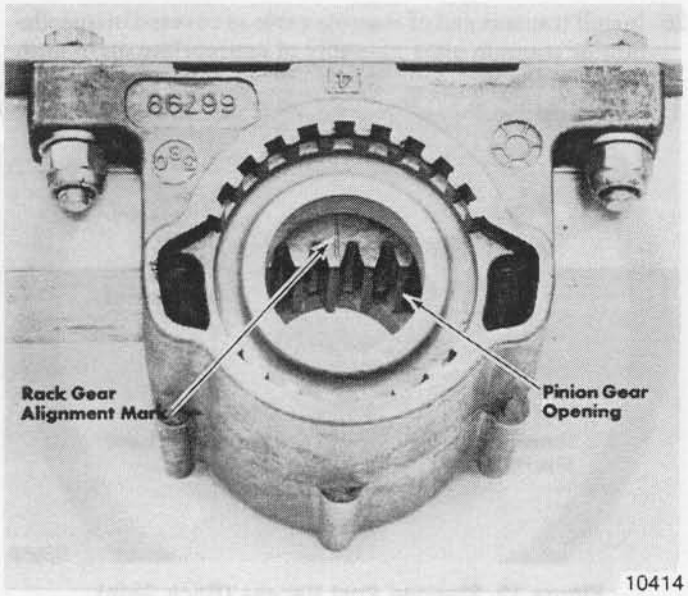


Figure 5. Centering Rack Gear in Pinion Gear Opening

Multipurpose Lubricant (C-92-63250), then install bushings (one each side) into pinion gear opening of gear rack assembly.

12. Insert pinion gear into gear rack assembly with smaller diameter spline end toward steering mount. (Figure 7 or 9) Place flat washer with large inside diameter over smaller spline end of pinion gear (toward steering mount).
13. Position gear rack assembly so that pinion gear is BELOW gear rack, as shown in Figures 5 and 6, then secure to mount as follows: ROUND RACK uses 2 lockwashers and two 3¼" (82.6mm) bolts, torqued to 25 ft. lbs. (3.46mkg). SQUARE RACK uses 2 flat washers and two 3½" (89mm) bolts with elastic locknuts, torqued to 12 ft. lbs. (1.66mkg).

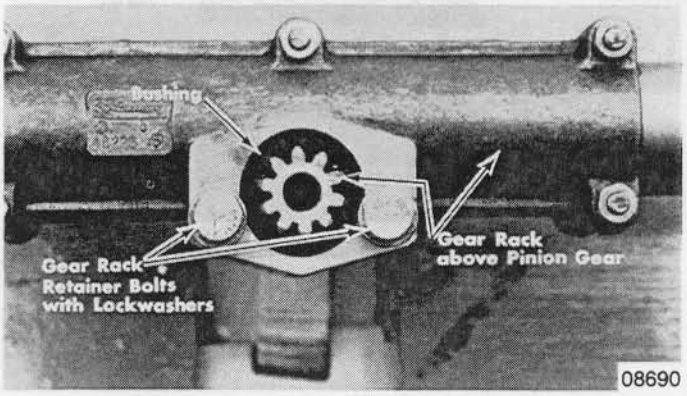


Figure 6. Installing Gear Rack - Round Rack

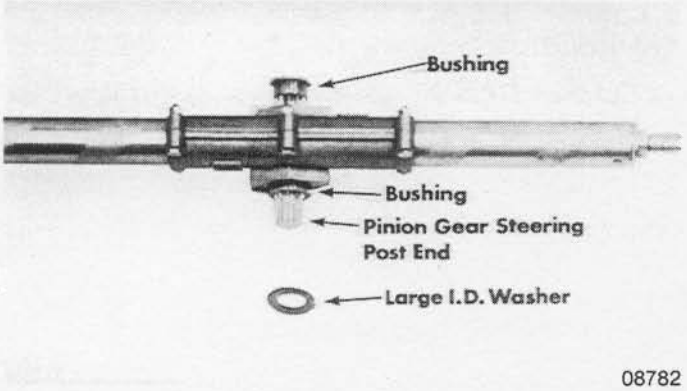


Figure 7. Installing Pinion Gear and Bushings - Round Rack

WARNING: Pinion gear MUST BE below rack gear after installation, or steering will be reversed.

14. Tighten steering cable jam nut securely against gear rack and torque to 35 ft. lbs. (4.84mkg). (Figure 8 or 14)
15. Place drive unit in straight forward position.
16. Lubricate nylon bushing (Figure 10 or 11) with Multipurpose Lubricant (C-92-63250) and install bushing into steering mount bracket.

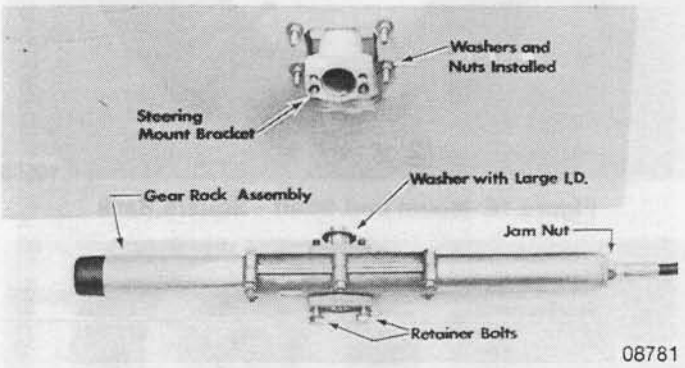


Figure 8. Gear Rack Ready to Mount

17. Lubricate splines of steering wheel shaft (these splines mate with pinion gear splines) with Multipurpose Lubricant. Install steering wheel shaft into steering mount with "square" of shaft positioned as shown in Figure 10 or 11.
18. With steering wheel shaft positioned as shown in Figure 10 or 11 and while holding pinion gear in position, engage splines in steering wheel shaft with splines on pinion gear.

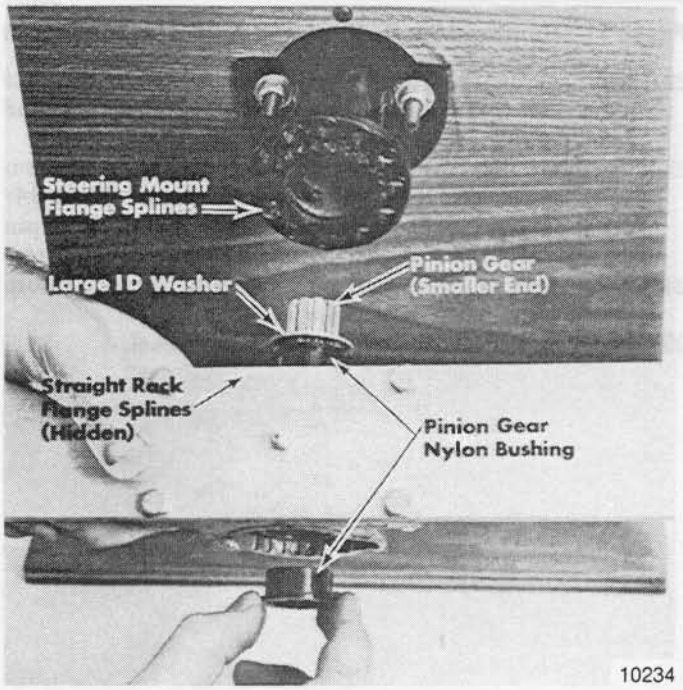


Figure 9. Installing Pinion Gear and Bushings - Square Rack

19. On LOCKING-type mounts, place lock plate over steering shaft. On NON-LOCKING mounts, place cover plate over steering shaft.
20. View steering wheel from back side. Steering post recess (square opening) has one flat side above spoke in steering wheel. (Figure 12)
21. Place steering wheel in position on steering shaft with flats aligned.

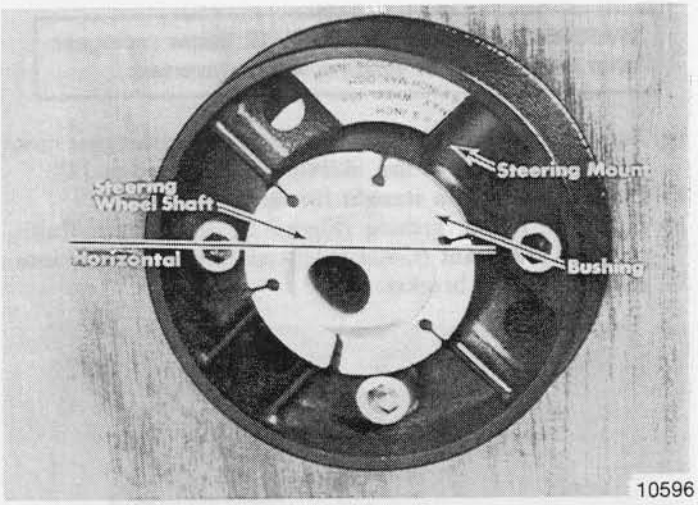


Figure 10. Mount and Shaft - Square Rack

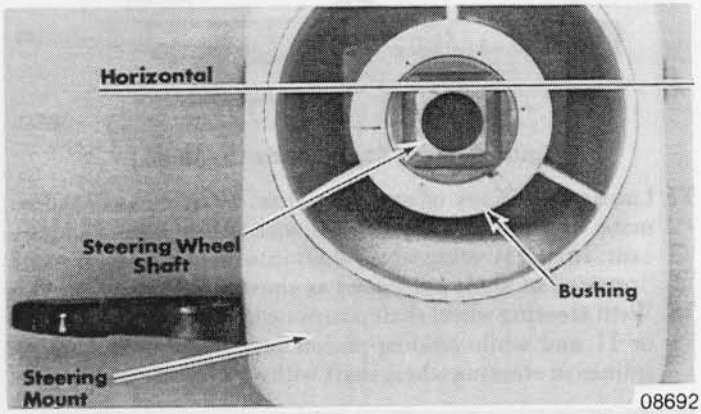


Figure 11. Mount and Shaft - Round Rack (Tilt Mount Shown)

22. Install thru bolt thru steering wheel, steering shaft and pinion gear. Clean grease from threads (which are exposed beyond pinion gear) of the thru bolt.
23. Place large flat washer over thru bolt and against pinion gear. Secure thru bolt with locknut. (Figure 13 or 14) Torque locknut to 80 in. lbs. (92kg-cm). Install cotter pin through hole at end of thru bolt. Spread ends of cotter pin.
24. Rotate steering wheel thru entire steering range to assure that no bind exists in cable or rack.
25. Install trim cover in center of steering wheel.
26. Install transom end of steering cable as covered in installation of transom plate assembly of appropriate drive unit. (See "Index".)

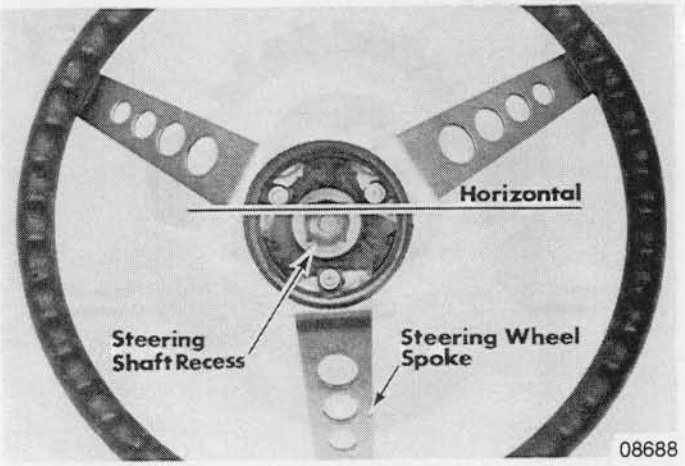


Figure 12. Steering Post Recess (Back Side)

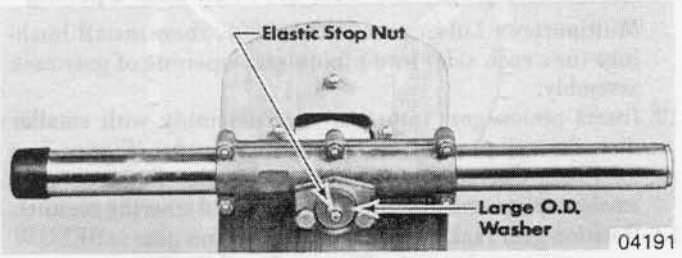


Figure 13. Rack Installed - Round Rack

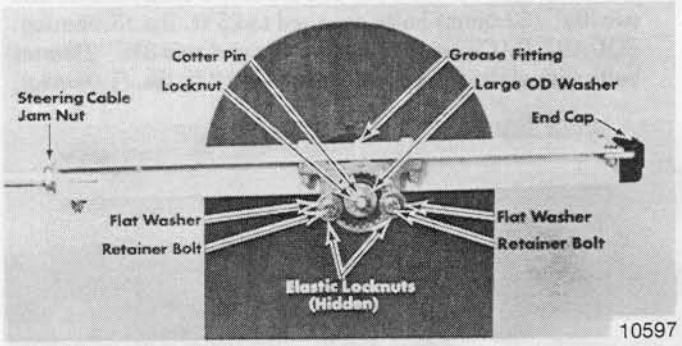


Figure 14. Rack Installed - Square Rack

ROTARY RIDE-GUIDE STEERING CABLE and HEAD REPLACEMENT

REMOVAL

1. Remove cover from steering wheel hub.
2. Remove elastic stop nut and washer from thru-bolt.
3. Remove 2 nuts and washers that hold housing assembly to steering wheel adaptor.
4. Slide gear housing and pinion assembly off thru-bolt.
5. Separate housing halves and remove cable.

INSTALLATION

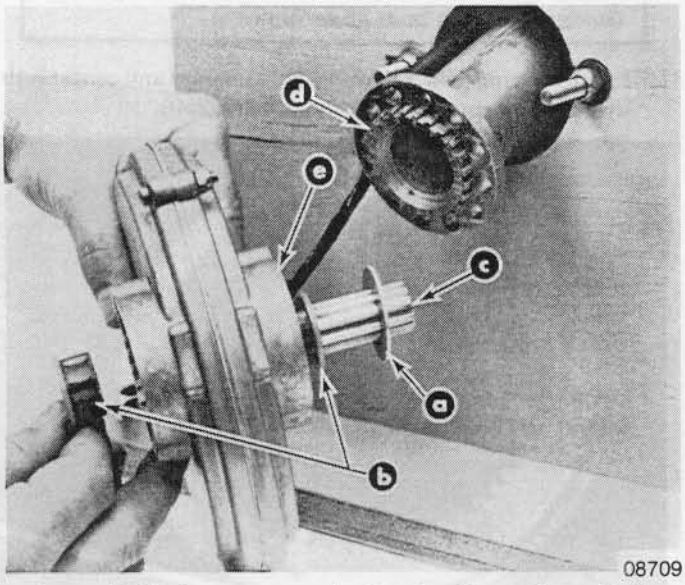
CAUTION: "Cable Installation - General", preceding, MUST BE read and followed before installing Ride-Guide cable into boat. (See "Index".)

1. Lubricate outer surface of pinion gear bushings with Multipurpose Lubricant (C-92-63250) and install bushings (one each side) into pinion gear openings of rotary head. (Figure 1)
2. Position rotary head with pinion gear opening BELOW that part of head where steering cable enters head.

WARNING: Pinion gear must be BELOW steering cable after installation, or steering will be reversed.

3. Install pinion gear into rotary head with smaller spline end toward steering mount. (Figure 1) Place large ID washer over smaller spline end of pinion gear.
4. Align splines of rotary head with splines of steering mount flange and install rotary head on steering mount.

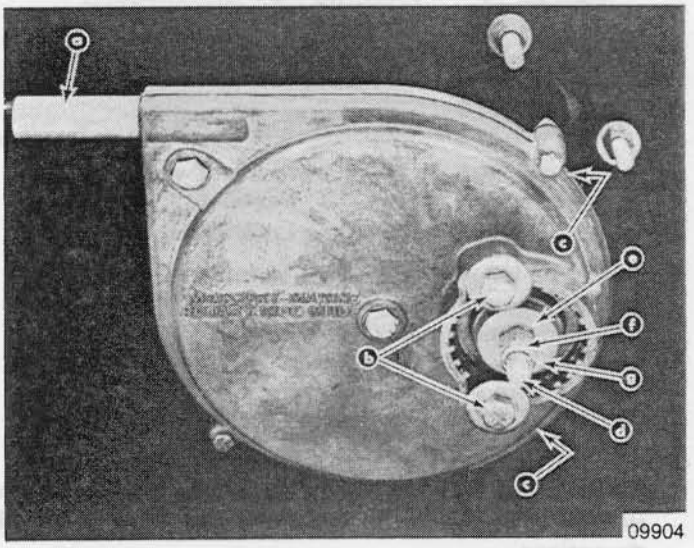
IMPORTANT: Rotary head and steering mount flange are designed to allow installation at 15-degree intervals. Select an installation position that will allow the most direct steering cable route with as large as possible steering cable radii.



a - Large ID Washer
b - Pinion Gear Bushings
c - Pinion Gear (Smaller End)
d - Steering Mount Flange Splines
e - Rotary Head Flange Splines (Hidden)

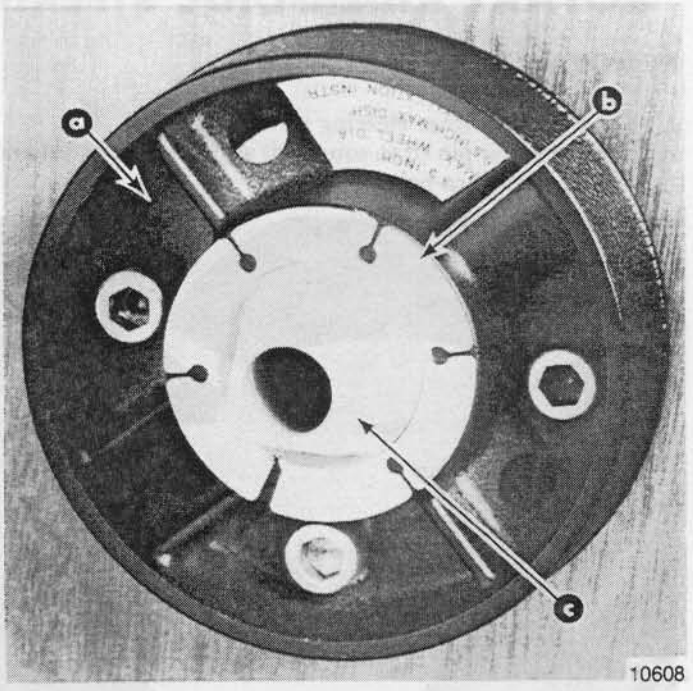
Figure 1. Installing Pinion Gear and Bushings into Rotary Head

5. Secure rotary head assembly to steering mount flange with flat washers, 3½" (89mm) long bolts and locknuts, as shown in Figure 2. Torque bolts to 12 ft. lbs. (1.66mkg).



a - Steering Cable
b - Flat Washers and 3-1/2" Bolts (Torque Bolts to 12 Ft. Lbs.)
c - Locknuts (Hidden)
d - Long Thru Bolt
e - Flat Washer
f - Locknut (Torque to 80 In. Lbs.)
g - Cotter Pin

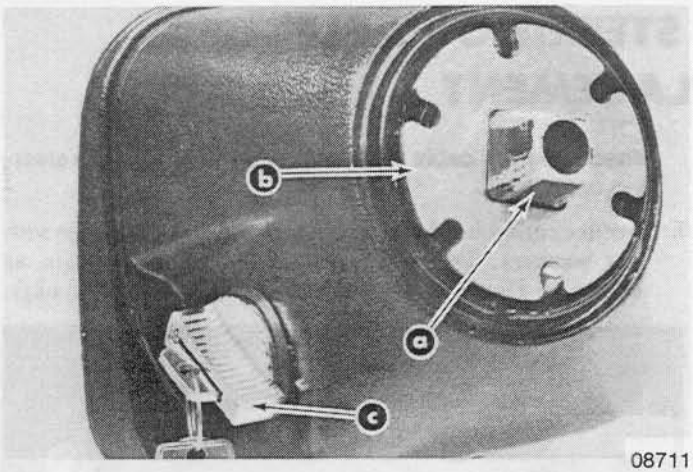
Figure 2. Installing Rotary Head to Steering Mount



a - Steering Mount b - Steering Shaft Bushing c - Steering Shaft

Figure 3. Installing Steering Shaft Bushing and Steering Shaft

6. Lubricate steering shaft bushing with Multipurpose Lubricant and install into steering mount. (Figure 3)
7. Lubricate splines of steering shaft (these splines mate with pinion gear splines) with Multipurpose Lubricant. While



a - Steering Shaft
b - Lock Plate
c - Ignition Switch ("Lock" Position)

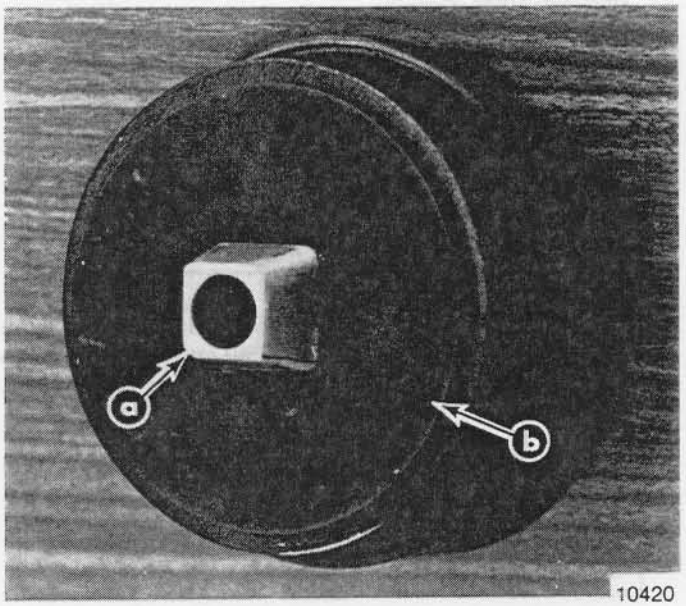
Figure 4. Installing Lock Plate

holding pinion gear in position, install steering shaft into steering mount and engage splines in steering shaft with splines on pinion gear. (Figure 3)

8. On LOCKING-type mounts, place lock plate over steering shaft. (Figure 4)
   On NON-LOCKING mounts, place cover plate over steering shaft. (Figure 5)

IMPORTANT: Refer to "Selecting a Steering Wheel" in steering wheel carton for recommended steering wheel dimensions.

9. Place steering wheel in position over steering shaft.
10. Install long thru bolt through steering wheel, steering shaft and steering pinion gear.
11. Clean grease from threads of thru bolt which are exposed beyond pinion gear.
12. Place large flat washer over thru bolt and against pinion gear. Secure thru bolt with locknut. (See Figure 2)
13. Torque locknut to 80 in. lbs. (92kg-cm).
14. Install cotter pin through hole at end of long thru bolt.
15. Place cover on steering wheel hub.
16. Install transom end of steering cable as covered in installation of transom plate assembly of appropriate drive unit. (See "Index".)



a - Steering Shaft
b - Cover Plate

Figure 5. Installing Cover Plate

ROTARY RIDE-GUIDE STEERING CABLE (ONLY) REPLACEMENT

REMOVAL

1. Remove cover from steering wheel hub.
2. Remove cotter pin (if so equipped) and elastic stop nut and washer from thru-bolt. (Figure 1)

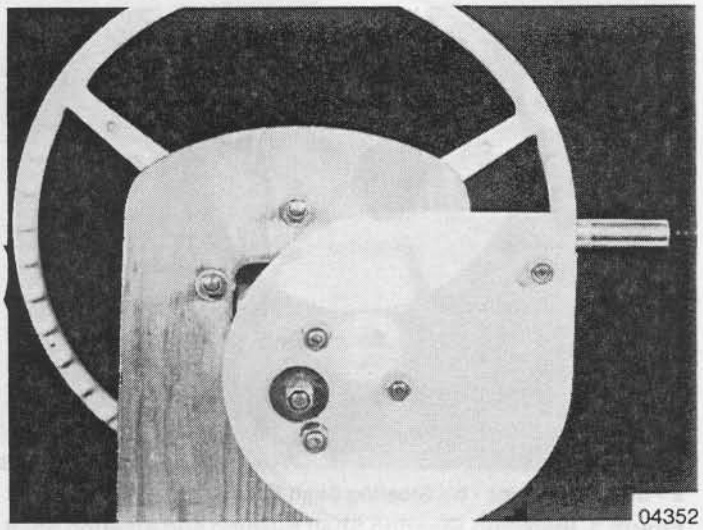


Figure 1. Cable Assembly Mounted

3. Remove 2 nuts and washers that hold housing assembly to steering wheel adaptor. (Figure 1)
4. Slide gear housing and pinion assembly off thru-bolt.
5. Separate housing halves and remove cable.

INSTALLATION

CAUTION: "Cable Installation - General", preceding, MUST BE read and followed before installing Ride-Guide cable into boat. (See "Index".)

1. Lubricate ring gear, left and right housings and center hub with Multipurpose Lubricant (C-92-63250).

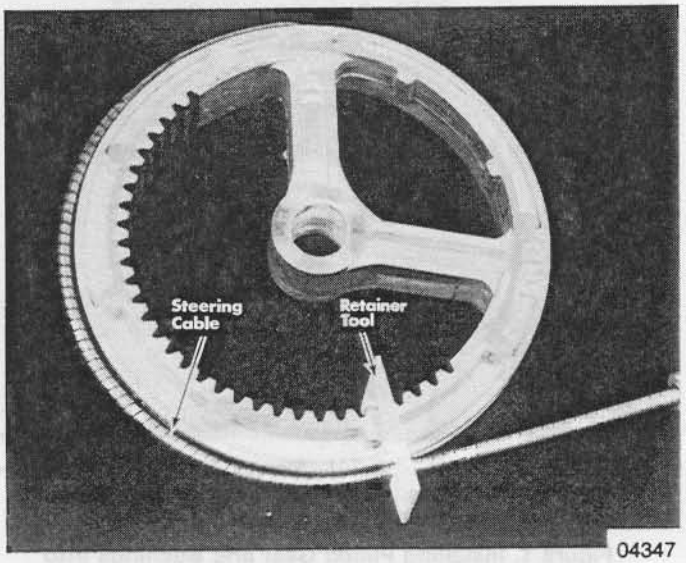


Figure 2. Installing Cable with Retaining Tool

2. While holding ring gear with gear teeth toward left side, install cable end into retaining hole in ring gear with cable extended in a counterclockwise direction. (Figure 2) Tap hooked end of cable lightly to seat into hole.
3. Wrap cable approximately ½-turn around ring gear in a counterclockwise direction and install Retainer Tool (C-91-54175) over ring gear and cable, as shown in Figure 2.
4. Install nyliner over ring gear and cable. Use grease (that is supplied) in groove of liner. DO NOT use Multipurpose Lubricant in this groove. Butt one end of liner against retainer tool.
5. Make certain that bushing is in center hole of ring gear and install ring gear over hub in housing. Press down evenly on ring gear and nylon liner to install in housing. (Figure 3) Remove retainer tool.
6. Place cable guide end into slots in housng. Position opposite housing over assembly and fasten with a 5/16-24x1¾" screw, 5/16-24x1⅛" screw, plain washers and 2 Eslok nuts.
7. Lubricate 2 nylon splined bushings with Multipurpose Lubricant and install a bushing into opening on both sides of gear and housing assembly.
8. Place pinion gear into ring gear with small diameter end extending out from side which will mount to steering wheel post adaptor.
9. Slide gear housing and pinion assembly over thru-bolt, fitting snugly into splined end of steering wheel shaft. Attach housing to adaptor with 2 washers and nuts.
10. Slide large washer over thru-bolt and fasten with elastic stop nut to hold in place. (Figure 1)

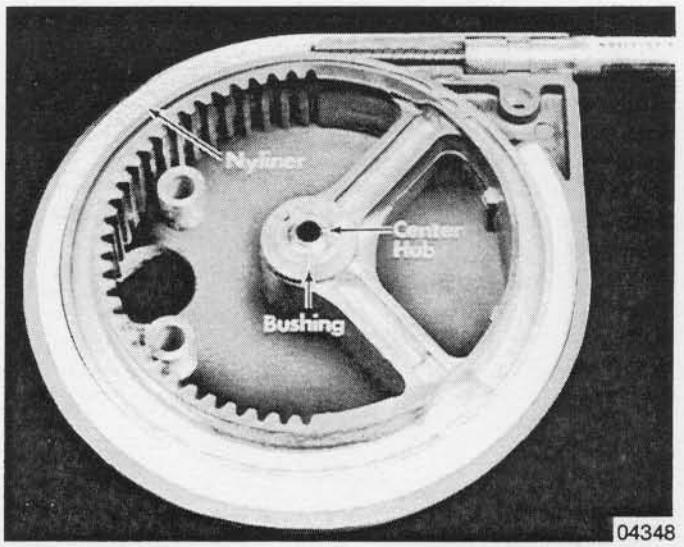
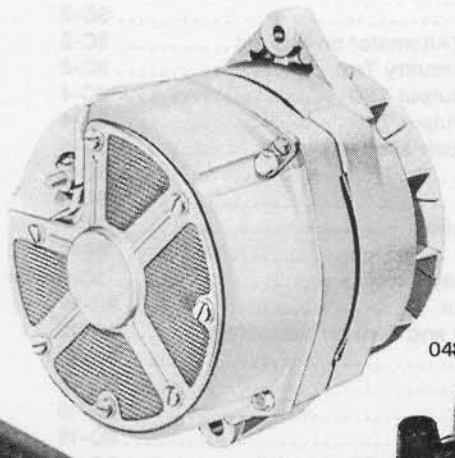


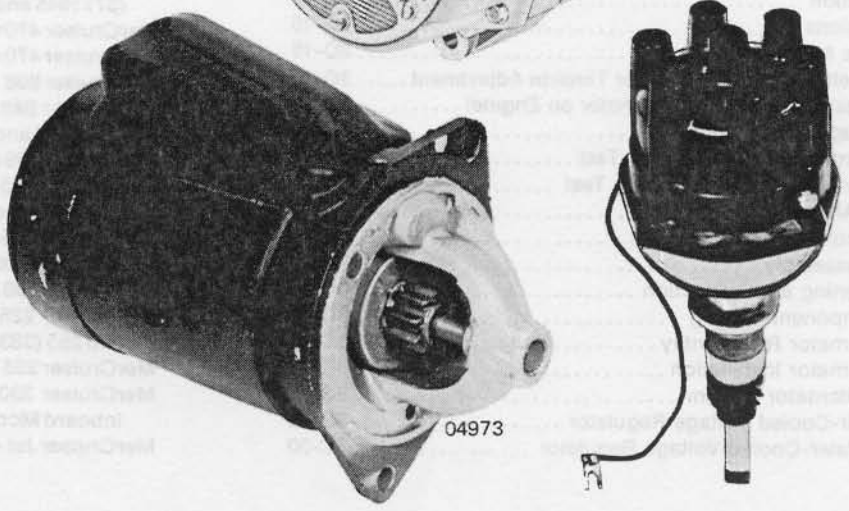
Figure 3. Ring Gear Installed

11. Torque elastic stop nut on thru-bolt to approximately 80 in. lbs. (92kg-cm) and install new cotter pin (if hole is provided).
12. Place cover on steering wheel hub.
13. Install transom end of steering cable as covered in installation of transom plate assembly of appropriate drive unit. (See "Index".)

ELECTRICAL SYSTEM

MERCRUISER Section 3





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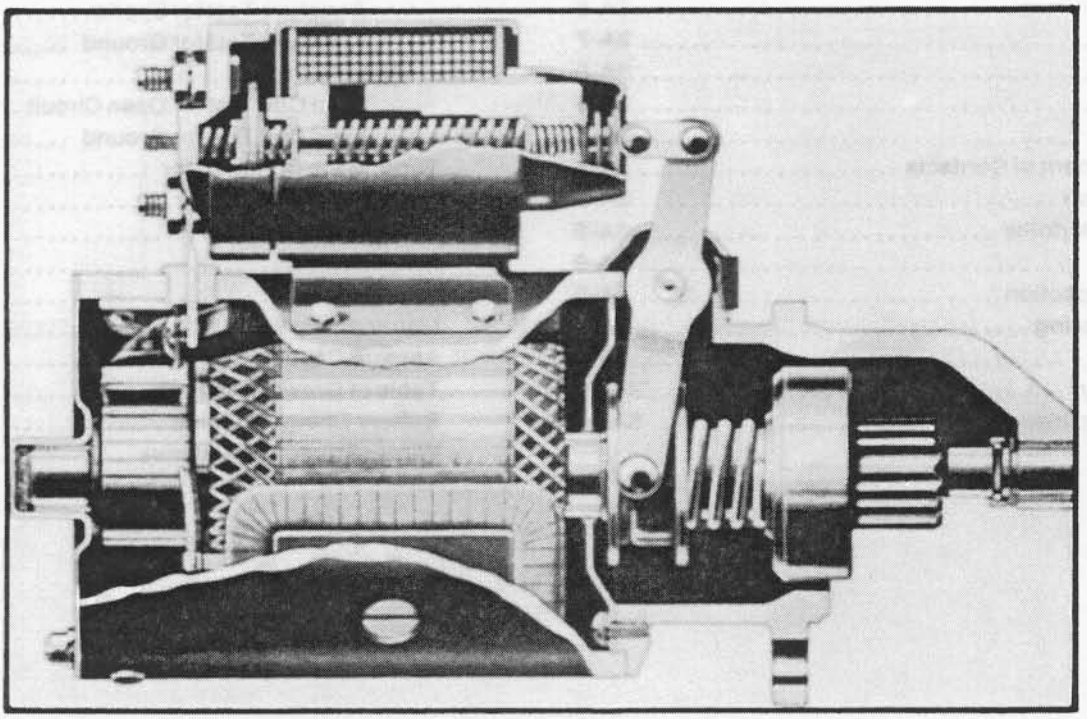
SECTION 3 - ELECTRICAL SYSTEM

PART A - STARTING SYSTEM



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STARTER MOTOR - DELCO REMY

Description

NOTE: Refer to Figure 2 for parts identification.

The function of the starting system is to crank the engine. The battery supplies electrical energy to the solenoid which closes the circuit between the battery and cranking motor, causing the cranking motor armature to rotate.

The solenoid also shifts the cranking motor pinion into mesh with the flywheel teeth, and engine cranking takes place.

Periodic lubrication of starter or solenoid is not required. Refer to "Specifications" Section 8 for starter specs.

Components

The starting system consists of (1) the starting motor, which is a pad-mounted 12-volt extruded frame type with 4 fields connected in series and an armature, (Figure 1) (2) a solenoid, a flange-mounted switch which operates an overrunning clutch drive, (Figure 1) (3) a battery and (4) the necessary wiring to connect these components.

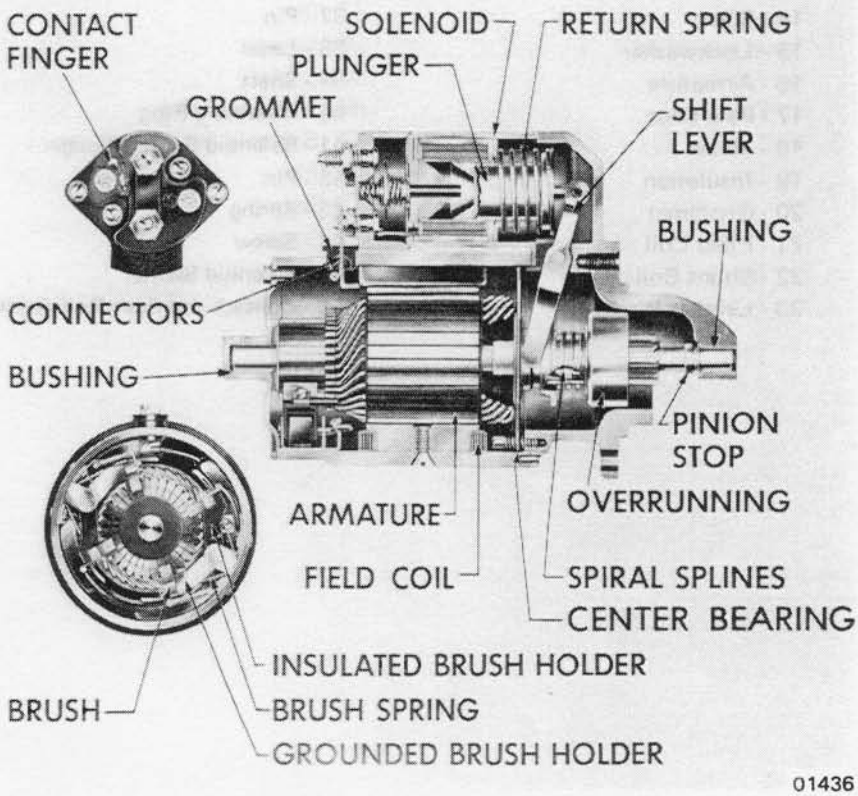

Figure 1. Starting Motor Cross Section

Precautions

The cranking motor is designed to operate under great overload and produce a high horsepower for its size. It can do this only for a short time, since considerable heat accumulates and can cause serious damage. For this reason, the cranking motor must never be used for more than 30 seconds at any one time. Cranking should not be repeated without a pause of at least 2 minutes to permit the heat to escape.

Periodic Inspection

Cranking motor and solenoid are completely enclosed in the drive housing to prevent entrance of moisture and dirt. However, as an aid to preventive maintenance, periodic inspection is required as follows:

1. Inspect terminals for corrosion and loose connections.
2. Inspect wiring for frayed and worn insulation.
3. Check mounting bolts for tightness.

Troubleshooting

Refer to "Troubleshooting" Section 10.

Parts Identification for Figure 2

1 - Housing
2 - Bushing
3 - Thrust Collar
4 - Ring
5 - Collar
6 - Overrunning Clutch
7 - Bushing
8 - Spring
9 - Collar
10 - Collar Lockwire
11 - Center Bearing Plate
12 - Bushing
13 - Washer
14 - Screw
15 - Lockwasher
16 - Armature
17 - Pole Shoe
18 - Screw
19 - Insulation
20 - Grommet
21 - Field Coil
22 - Shunt Coil
23 - Leather Washer
24 - Commutator End Frame
25 - Thru Bolt
26 - Insulated Brush Holder
27 - Ground Brush Holder
28 - Brush
29 - Screw
30 - Support
31 - Pin
32 - Lead
33 - Screw
34 - Lockwasher
35 - Nut
36 - Spring
37 - Pin
38 - Lever
39 - Shaft
40 - Retaining Ring
41 - Solenoid Switch Plunger
42 - Pin
43 - Spring
44 - Screw
45 - Solenoid Switch
46 - Contact and Push Rod Assembly
47 - Spring
48 - Solenoid Switch Cover
49 - Stud
50 - Resistor Terminal Stud Contact
51 - Lockwasher
52 - Nut
53 - Stud
54 - Stud
55 - Washer
56 - Nut
57 - Lockwasher
58 - Nut
59 - Stud
60 - Clip
61 - Plastic Washer
62 - Nut
63 - Lockwasher
64 - Screw
65 - Plastic Washer
66 - Screw
67 - Lockwasher
68 - Connector

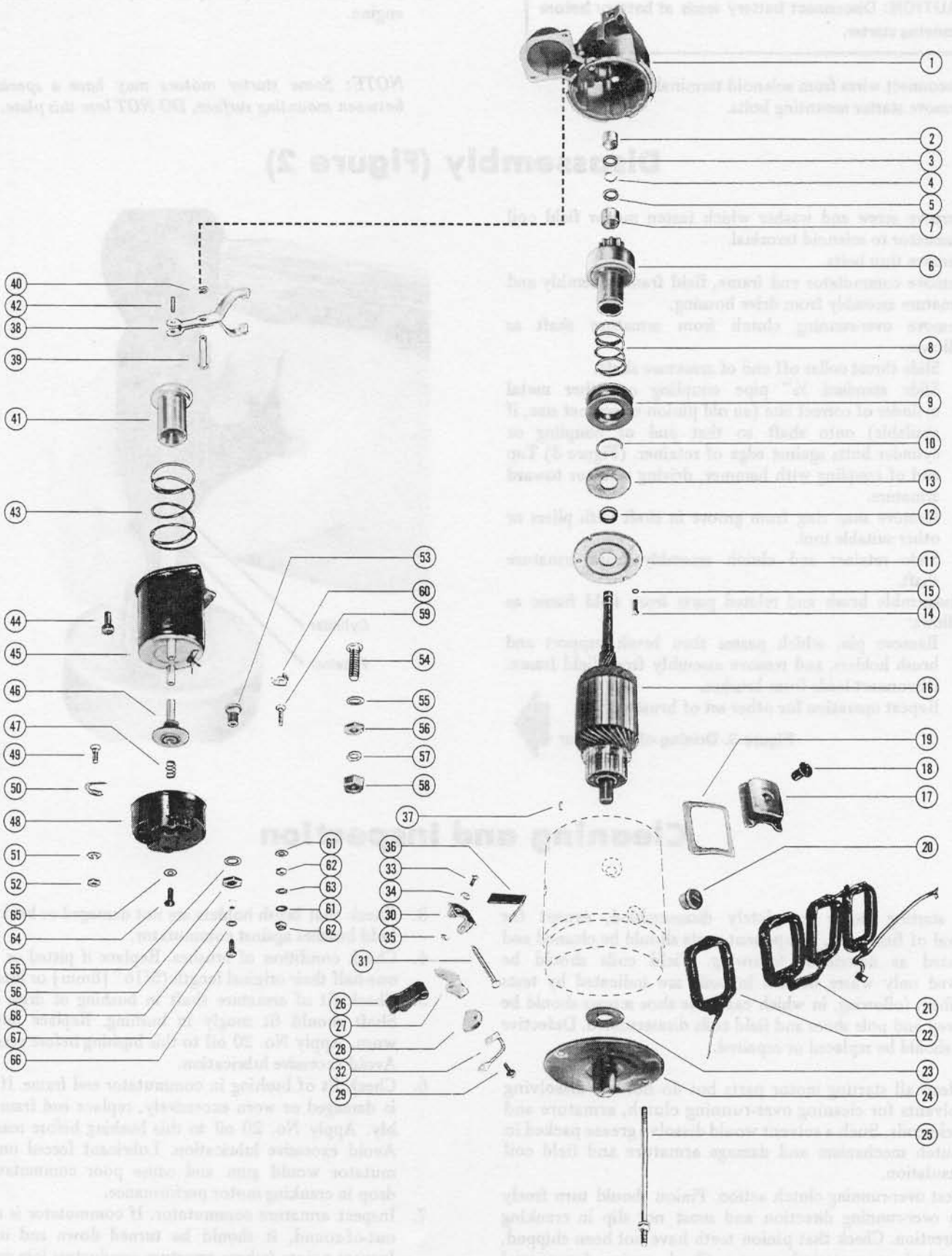

Figure 2. Typical Delco Starting Motor

Removal

CAUTION: Disconnect battery leads at battery before removing starter.

1. Disconnect wires from solenoid terminals.
2. Remove starter mounting bolts.
3. Pull starter assembly away from flywheel and remove from engine.

NOTE: Some starter motors may have a special plate between mounting surface. DO NOT lose this plate.

Disassembly (Figure 2)

1. Remove screw and washer which fasten motor field coil connector to solenoid terminal.
2. Remove thru bolts.
3. Remove commutator end frame, field frame assembly and armature assembly from drive housing.
4. Remove over-running clutch from armature shaft as follows:
   a. Slide thrust collar off end of armature shaft.
   b. Slide standard ½" pipe coupling or other metal cylinder of correct size (an old pinion of correct size, if available) onto shaft so that end of coupling or cylinder butts against edge of retainer. (Figure 3) Tap end of coupling with hammer, driving retainer toward armature.
   c. Remove snap ring from groove in shaft with pliers or other suitable tool.
   d. Slide retainer and clutch assembly from armature shaft.
5. Disassemble brush and related parts from field frame as follows:
   a. Remove pin, which passes thru brush support and brush holders, and remove assembly from field frame.
   b. Disconnect leads from brushes.
   c. Repeat operation for other set of brushes.

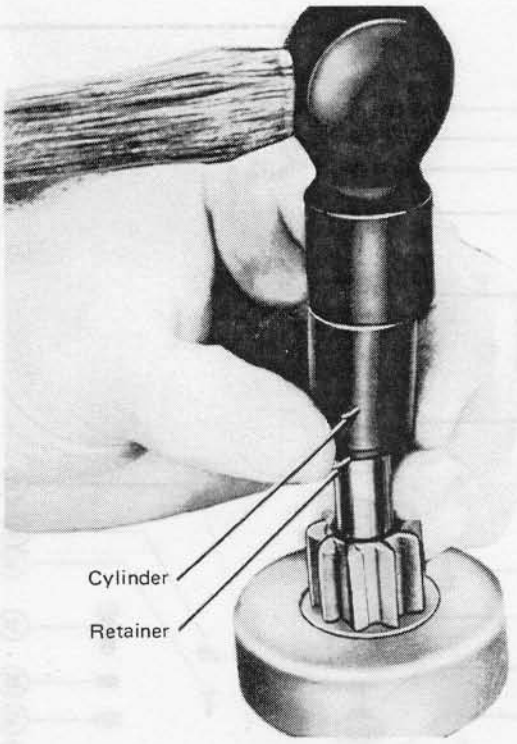

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Figure 3. Driving off Retainer

Cleaning and Inspection

With starting motor completely disassembled, except for removal of field coils, component parts should be cleaned and inspected as described, following. Field coils should be removed only where defects in coils are indicated by tests described, following, in which case pole shoe screws should be removed and pole shoes and field coils disassembled. Defective parts should be replaced or repaired.

1. Clean all starting motor parts but do not use dissolving solvents for cleaning over-running clutch, armature and field coils. Such a solvent would dissolve grease packed in clutch mechanism and damage armature and field coil insulation.
2. Test over-running clutch action. Pinion should turn freely in over-running direction and must not slip in cranking direction. Check that pinion teeth have not been chipped, cracked or excessively worn. Check spring for normal tension and drive collar for wear. If necessary, replace spring or collar by forcing collar toward clutch and removing lock ring from end of tube.
3. Check that brush holders are not damaged or bent and will hold brushes against commutator.
4. Check condition of brushes. Replace if pitted or worn to one-half their original length (5/16" [8mm] or less).
5. Check fit of armature shaft in bushing of drive housing. Shaft should fit snugly in bushing. Replace bushing, if worn. Apply No. 20 oil to this bushing before reassembly. Avoid excessive lubrication.
6. Check fit of bushing in commutator end frame. If bushing is damaged or worn excessively, replace end frame assembly. Apply No. 20 oil to this bushing before reassembly. Avoid excessive lubrication. Lubricant forced onto commutator would gum and cause poor commutation and drop in cranking motor performance.
7. Inspect armature commutator. If commutator is rough or out-of-round, it should be turned down and undercut. Inspect points (where armature conductors join commutator bars) to make sure that it is a good, firm connection. Burned commutator bar usually is evidence of poor connection. See "Turning the Commutator"; see "Index".

ARMATURE

ARMATURE TEST for SHORTS

Check armature for short circuits by placing on growler and holding hack saw blade over armature core while rotating armature. (Figure 4) If saw blade vibrates, armature is shorted. After cleaning between commutator bars, recheck armature on growler. If saw blade still vibrates, replace armature.

ARMATURE TEST for GROUND

1. With continuity meter or lamp, place one lead on armature core or shaft and other lead on commutator.

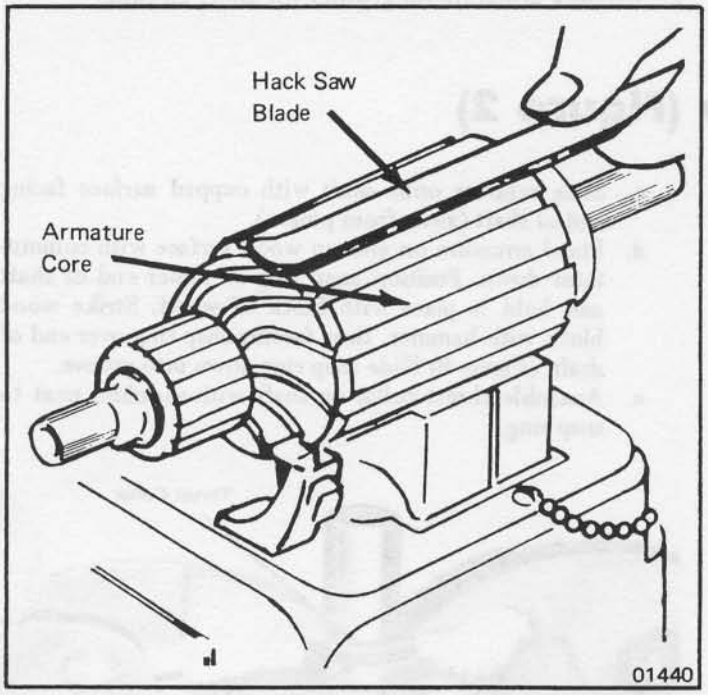

Figure 4. Armature Tests for Shorts

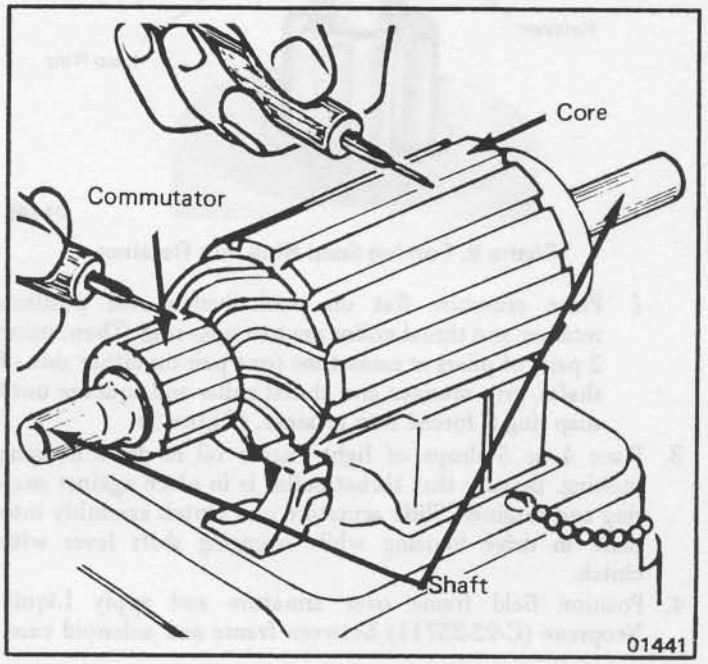

Figure 5. Armature Test for Ground Field Coil

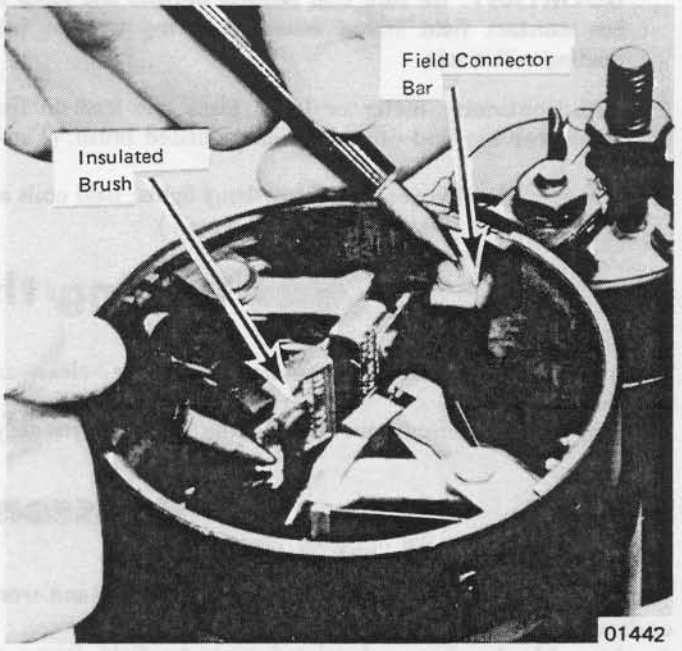

Figure 6. Field Coil Test for Open Circuit

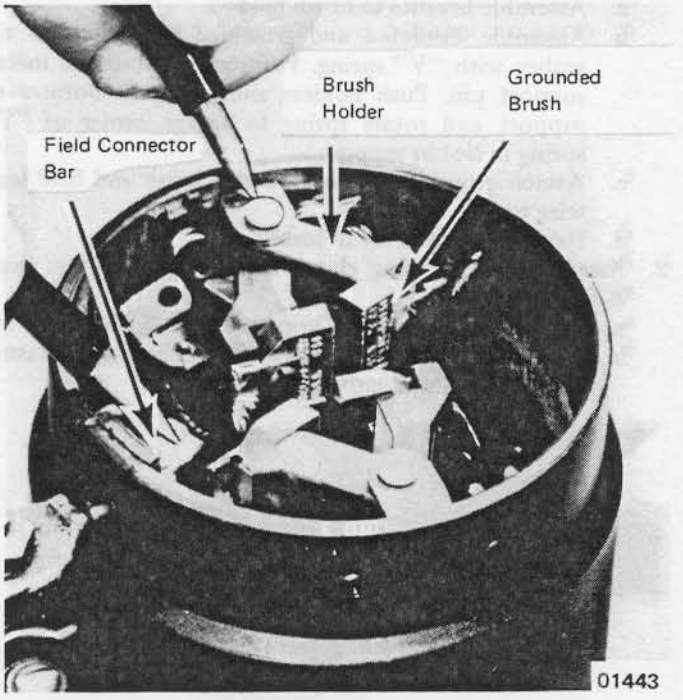

Figure 7. Field Coil Test for Ground

2. If meter hand moves to right or lamp lights, armature is grounded and must be replaced. (Figure 5)

FIELD COIL

FIELD COIL TEST for OPEN CIRCUIT

1. With continuity meter or lamp, place one lead on each end of field coils (insulated brush and field connector bar.) (Figure 6)
2. If meter hand does not move to right or lamp does not light, field coils are open and must be replaced.

FIELD COIL TEST for GROUND

IMPORTANT: Be sure that positive brushes and leads do not contact field frame assembly during test, or false reading will result.

1. With continuity meter or lamp, place one lead on field connector bar and other lead on grounded brush. (Figure 7)
2. If meter hand moves to right or lamp lights, field coils are grounded and must be replaced. (Figure 7)

LOOSE ELECTRICAL CONNECTIONS

If open soldered connection of armature to commutator leads is found during inspection, resolder with rosin flux.

CAUTION: Never use acid flux on electrical connections.

Turning the Commutator

When inspection shows commutator roughness, clean as follows:

1. Turn down commutator in a lathe until thoroughly cleaned.
2. Recheck armature on growler for short circuits.

Reassembly (Figure 2)

After all parts are thoroughly tested and inspected and worn or damaged parts replaced, reassemble starter as follows:

1. Assemble brushes and related parts to field frame as follows:
   a. Assemble brushes to brush holders.
   b. Assemble insulated and grounded brush holders together with "V" spring. Position as a unit and install support pin. Push holders and spring to bottom of support and rotate spring to engage center of "V" spring in slot in support.
   c. Attach ground wire to grounded brush and field lead wire to insulated brush.
   d. Repeat for other set of brushes.
2. Assemble over-running clutch assembly to armature shaft as follows:
   a. Lubricate drive end of armature shaft with No. 10 oil.
   b. Slide assist spring and clutch assembly onto armature shaft with pinion outward.

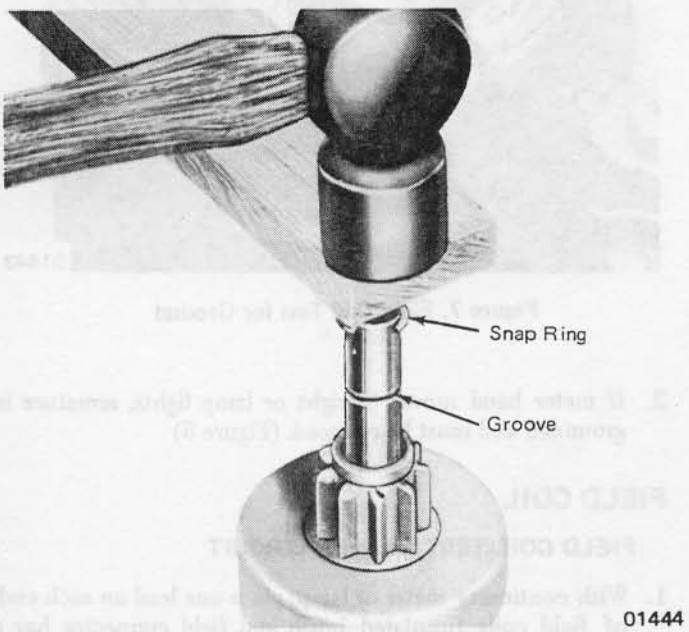

Figure 8. Forcing Snap Ring over Shaft

   c. Slide retainer onto shaft with cupped surface facing end of shaft (away from pinion).
   d. Stand armature on end on wood surface with commutator down. Position snap ring on upper end of shaft and hold in place with block of wood. Strike wood block with hammer, thus forcing snap ring over end of shaft. (Figure 8) Slide snap ring down into groove.
   e. Assemble thrust collar on shaft with shoulder next to snap ring.

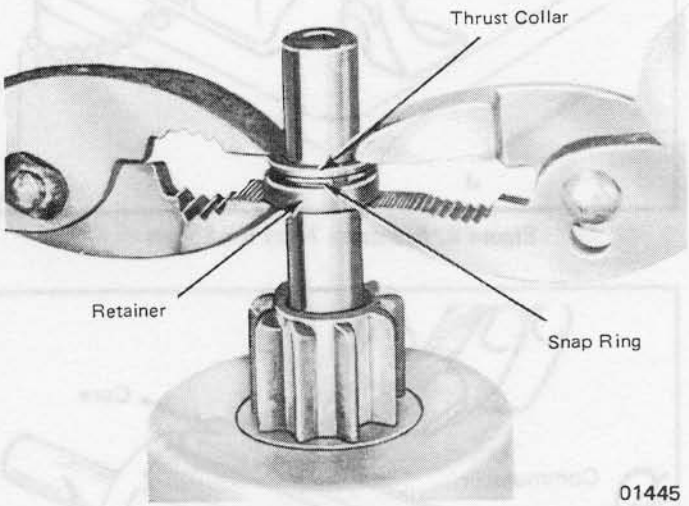

Figure 9. Forcing Snap Ring into Retainer

   f. Place armature flat on work bench and position retainer and thrust collar next to snap ring. Then, using 2 pairs of pliers at same time (one pair on either side of shaft), grip retainer and thrust collar and squeeze until snap ring is forced into retainer. (Figure 9)
3. Place 4 or 5 drops of light engine oil in drive housing bushing. Be sure that thrust collar is in place against snap ring and retainer. Slide armature and clutch assembly into place in drive housing while engaging shift lever with clutch.
4. Position field frame over armature and apply Liquid Neoprene (C-92-25711) between frame and solenoid case.

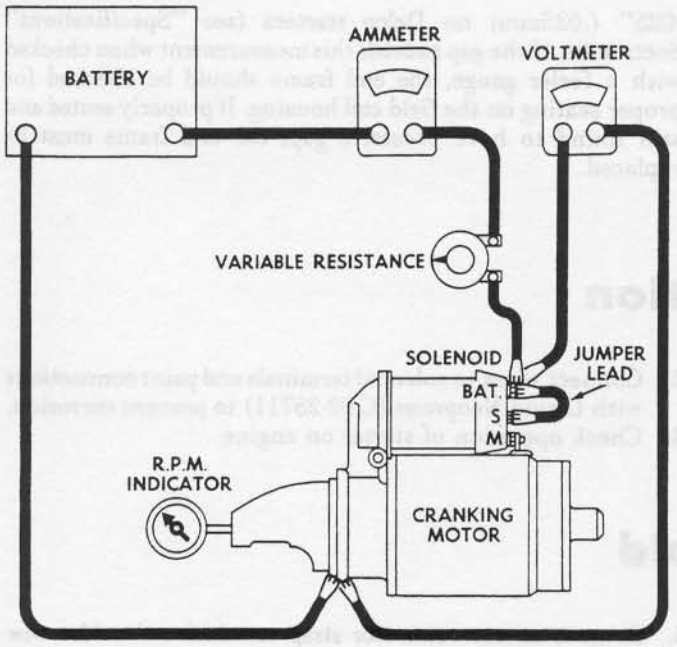

Figure 10. No Load Test Hookup

Position frame against drive housing, observing caution to prevent damage to brushes.

5. Place 4 to 5 drops of light engine oil in bushing in commutator end frame. Place leather brake washer on armature shaft and slide commutator end frame onto shaft.
6. Reconnect field coil connector to "motor" solenoid terminal.
7. After reassembly, a "no load" check of starting motor may be made if equipment is available. To check, connect starter motor in series with a fully-charged 12-volt battery, an ammeter capable of reading several hundred amperes and a variable resistance.
   Also connect a voltmeter, as illustrated, from motor terminal to motor frame. An RPM indicator is necessary to measure armature speed. (Figure 10) Obtain specified voltage by varying resistance unit. Then read current draw and armature speed and compare these readings with values listed below.

   Volts -- 10.6 Amperes -- 49-76 RPM -- 6200-9400
8. If readings are not correct, refer to "Troubleshooting" Section 10.
9. If the readings obtained are within limits, refer next to "Clearances", following, for important final checks before reinstallation.

Clearances

PINION CLEARANCE

Pinion clearance must be checked after reassembly of motor to insure proper adjustment. Check pinion clearance as follows:

1. Disconnect motor field coil connector from solenoid motor terminal and insulate it carefully.
2. Connect 12-volt battery from solenoid switch(s) terminal to solenoid frame. (Figure 11)
3. Momentarily touch a jumper lead from solenoid motor terminal to starter motor frame. This shifts pinion into cranking position where it will remain until battery is disconnected.
4. Push pinion back toward commutator end to eliminate slack movement.

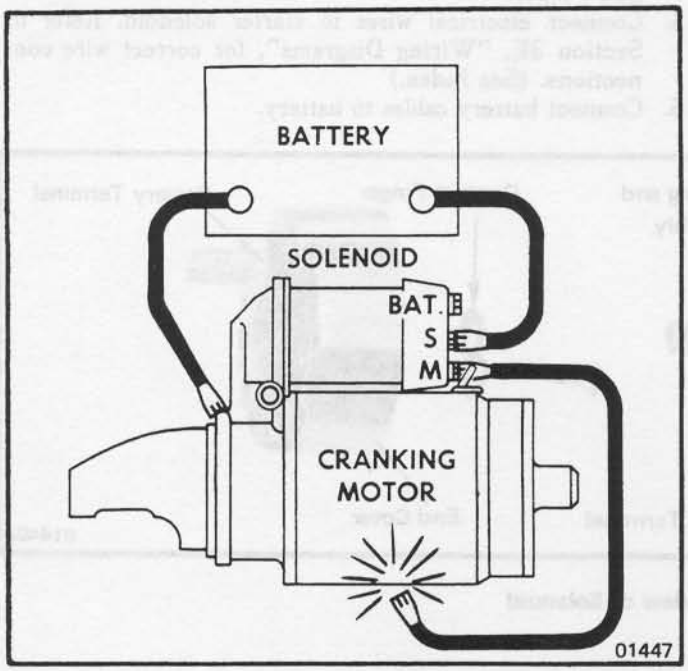

Figure 11. Circuit for Checking Pinion Clearance

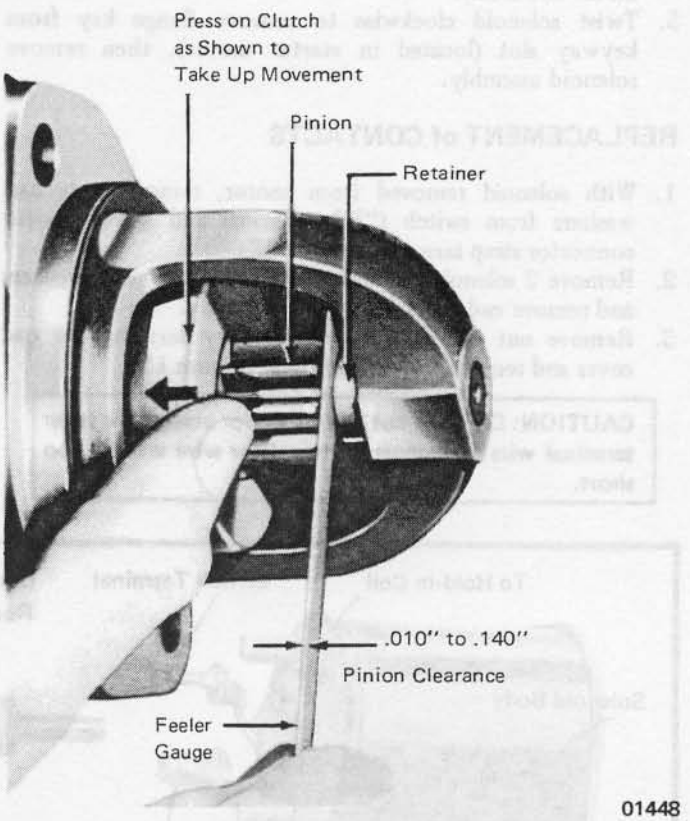

Figure 12. Checking Pinion Clearance

5. Measure distance between pinion and pinion stop. (Figure 12)
6. If clearance is not within specified limits (.010"-.140") (.025mm-3.556mm), it may indicate excessive wear of solenoid linkage shift lever yoke buttons or improper assembly of shift lever mechanism. Replace worn or defective parts, since no provision is made for adjusting pinion clearance.

COMMUTATOR END FRAME GAP

In order to maintain the ignition-proof characteristics designed into the starter for safety, the gap between the commutator end frame (Item 24 in Figure 2) and the starter field coil housing must be checked. Generally, no gap will be found. At no time, however, must the gap be allowed to exceed .025" (.635mm) on Delco starters (see "Specifications" Section 8). If the gap exceeds this measurement when checked with a feeler gauge, the end frame should be checked for proper seating on the field coil housing. If properly seated and still found to have excessive gap, the end frame must be replaced.

Installation

1. Place starting motor and solenoid assembly in position and install mounting bolts.
2. Fasten yellow lead wire to solenoid "S" terminal and red lead wires to solenoid battery terminal.
3. Connect wires to solenoid terminals and paint connections with Liquid Neoprene (C-92-25711) to prevent corrosion.
4. Check operation of starter on engine.

Solenoid

REMOVAL

1. Disconnect battery cables from battery.
2. Disconnect electrical wires from starter solenoid.
3. Remove screw and washer from starter motor connector strap terminal.
4. Remove 2 screws which hold solenoid assembly to starter motor end frame.
5. Twist solenoid clockwise to remove flange key from keyway slot (located in starter motor), then remove solenoid assembly.

REPLACEMENT of CONTACTS

1. With solenoid removed from motor, remove nuts and washers from switch ("S") terminal and starter motor connector strap terminal. (Figure 13)
2. Remove 2 solenoid end cover retaining screws and washers and remove end cover from solenoid body.
3. Remove nut and washer from battery terminal on end cover and remove battery terminal. (Figure 15)

CAUTION: DO NOT cut starter motor connector strap terminal wire to remove terminal, or wire will be too short.

4. Remove motor connector strap terminal and solder new terminal in position.
5. Remove and install new battery terminal, washer and retaining nut to end cover.
6. Place new contact ring and push rod assembly in solenoid housing.
7. Position end cover over switch and motor terminals and install end cover retaining screws. Also install washers and nuts on solenoid switch and starting motor terminals.

INSTALLATION

1. Install solenoid return spring on plunger.
2. Position solenoid assembly to starter motor end frame and turn solenoid counterclockwise to engage flange key in keyway slot.
3. Install (and tighten securely) 2 screws which hold solenoid assembly to end frame.
4. Secure starter motor connector strap terminal with screw and washer.
5. Connect electrical wires to starter solenoid. Refer to Section 3E, "Wiring Diagrams", for correct wire connections. (See Index.)
6. Connect battery cables to battery.

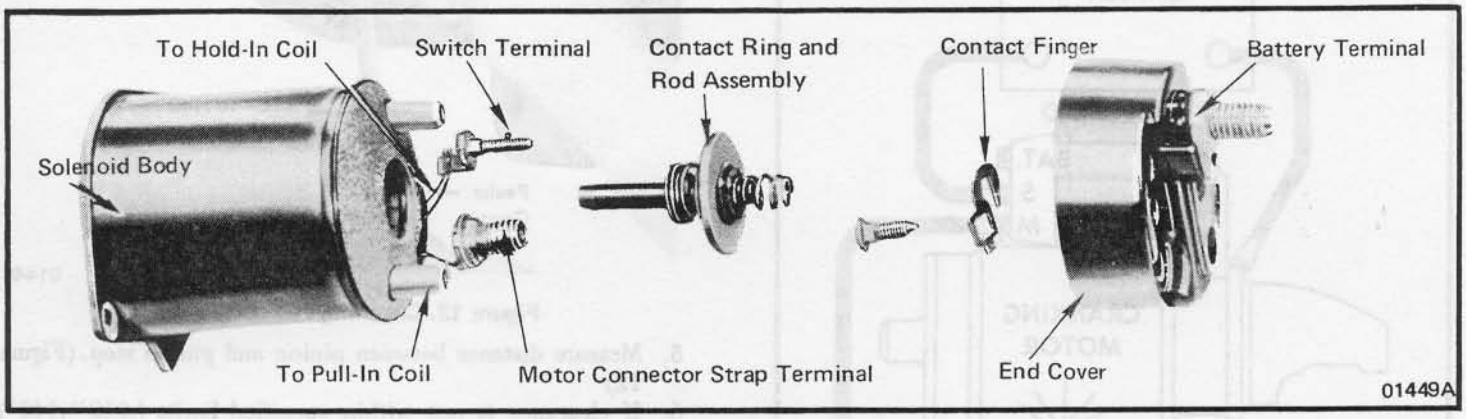

Figure 13. Exploded View of Solenoid

STARTER MOTOR - AUTOLITE

Description

NOTE: Refer to Figure 4, following, for parts identification.

The starter utilizes an integral positive-engagement drive. When the starter is first connected to the battery, current flows through the grounded field coil, actuating a movable pole shoe. The pole shoe is attached to the starter drive plunger lever and, thus, the drive is forced into engagement with the flywheel.

When the movable pole shoe is fully seated, it opens the field coil grounding contacts, and the starter then is turning the engine. A holding coil is used to maintain the movable pole shoe in the fully-seated position during the time that the starter is turning the engine.

Periodic lubrication of starting motor is not required. For specifications, refer to Section 8.

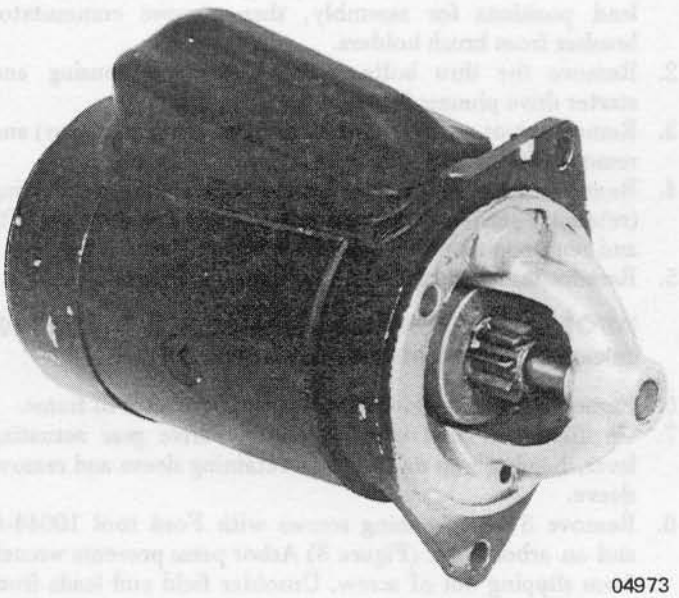

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Figure 1. Positive Engagement Starters

Periodic Inspection

Cranking motor is completely enclosed in drive housing to prevent entry of moisture and dirt. However, as an aid to preventive maintenance, periodic inspection is required as follows:

1. Inspect terminals for corrosion and loose connections.
2. Inspect wiring for frayed and worn insulation.
3. Check mounting bolts for tightness.

Troubleshooting

Refer to Section 10, "Troubleshooting".

Removal

CAUTION: Disconnect battery cables at battery before removing starter.

1. Disconnect yellow starter cable at starter terminal.
2. Remove starter mounting bolts. (Figure 2)
3. Pull starter assembly away from flywheel and remove from engine.

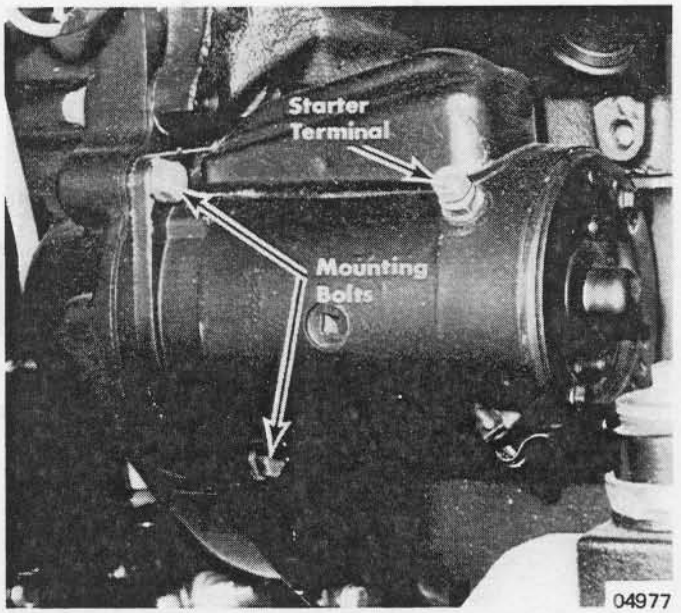

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Figure 2. Starter Mounting

Disassembly

1. Loosen brush cover band retaining screw and remove brush cover band and starter drive plunger lever cover. Observe lead positions for assembly, then remove commutator brushes from brush holders.
2. Remove the thru bolts, starter drive end housing and starter drive plunger lever return spring.
3. Remove pivot pin (retaining starter gear plunger lever) and remove lever and armature.
4. Remove stop ring retainer. Remove and discard stop ring (retaining starter drive gear to end of the armature shaft) and remove starter drive gear assembly.
5. Remove brush end plate.

IMPORTANT: DO NOT perform Steps 6, 7, 8, 9 or 10, unless replacement of those parts are necessary.

6. Remove 2 screws which secure ground brushes to frame.
7. On field coil that operates starter drive gear actuating lever, bend tab up on field coil retaining sleeve and remove sleeve.
8. Remove 3 coil retaining screws with Ford tool 10044-A and an arbor press. (Figure 3) Arbor press prevents wrench from slipping out of screw. Unsolder field coil leads from terminal screw and remove pole shoes and coils from frame. Use a 300-watt iron.
9. Cut (or unsolder) insulated brush leads from field coils as close to field connection point as possible.
10. Remove starter terminal nut, washer, insulator and terminal from starter frame. Remove any excess solder from terminal slot.

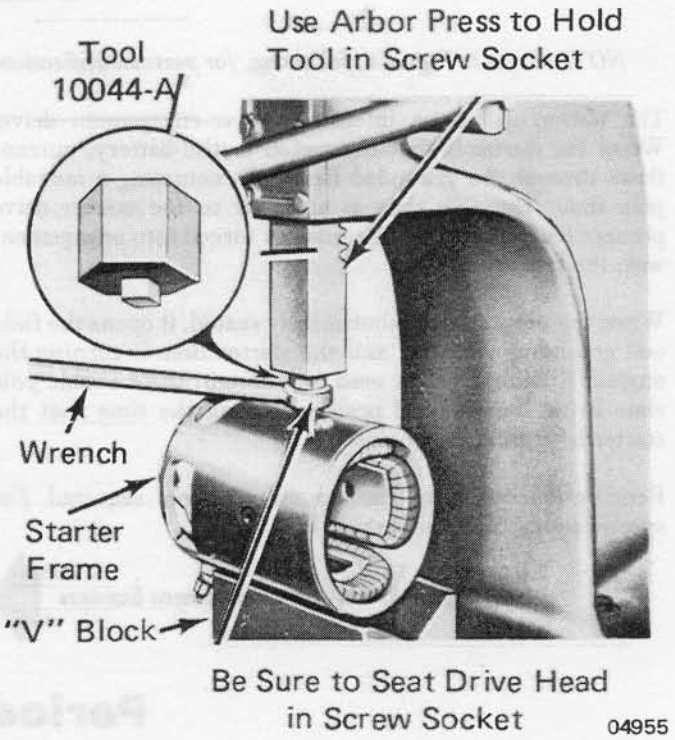


Figure 3. Pole Shoe Screw Removal

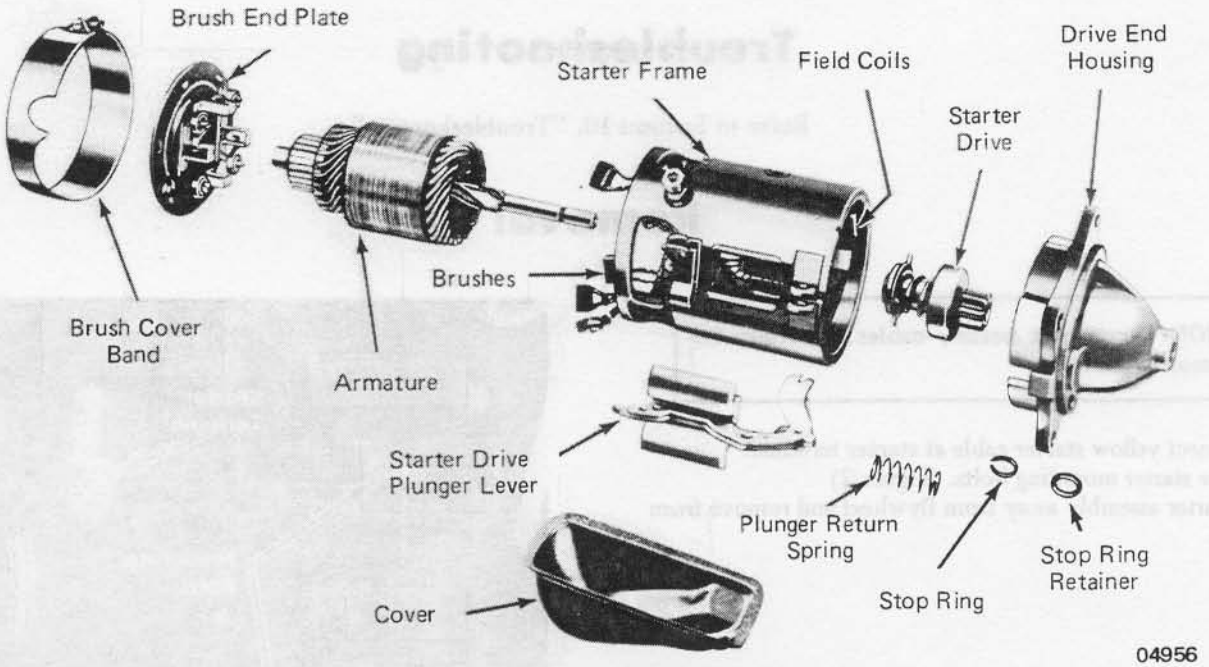


Figure 4. Starter - Exploded View

Cleaning and Inspection

CAUTION: DO NOT use grease dissolving solvents for cleaning electrical components of starter motor. Such solvents will damage insulation.

1. Use a brush or compressed air to clean field coils, armature, commutator, armature shaft, brush end plate and drive end housing. Wash all other parts in solvent and dry parts with compressed air.
2. Inspect armature windings for broken or burned insulation and unsoldered connections.
3. Check armature for open circuits and grounds. (Refer to "Component Checks", following.)
4. Inspect armature shaft and 2 bearings for scoring and excessive wear. If commutator is rough or out-of-round, turn it down. Refer to "Turning the Commutator"; see "Index".
5. Check brush holders for broken springs and insulated brush holders for shorts to ground. Tighten rivets that may be loose. Replace brushes, if worn to ¼" (6.35mm) or less in length.
6. Check brush spring tension. Replace springs if tension is not within specified limits (40 ounces minimum).
7. Inspect field coils for burned or broken insulation and continuity. Check field brush connections and lead insulation. A brush kit and a contact kit are available. (Refer to "Component Checks", following.)
8. Examine wear pattern on starter drive teeth. Pinion teeth must penetrate to a depth greater than ½ ring gear tooth depth to eliminate premature ring gear and starter drive failure.
9. Replace starter drives and ring gears with milled, pitted or broken teeth or those which show evidence of inadequate engagement.

Component Checks

ARMATURE

ARMATURE TEST for SHORTS

Check armature for short circuits by placing on growler and holding hack saw blade over armature core while rotating armature. (Figure 5) If saw blade vibrates, armature is shorted. After cleaning between commutator bars, recheck armature on growler. If saw blade still vibrates, replace armature.

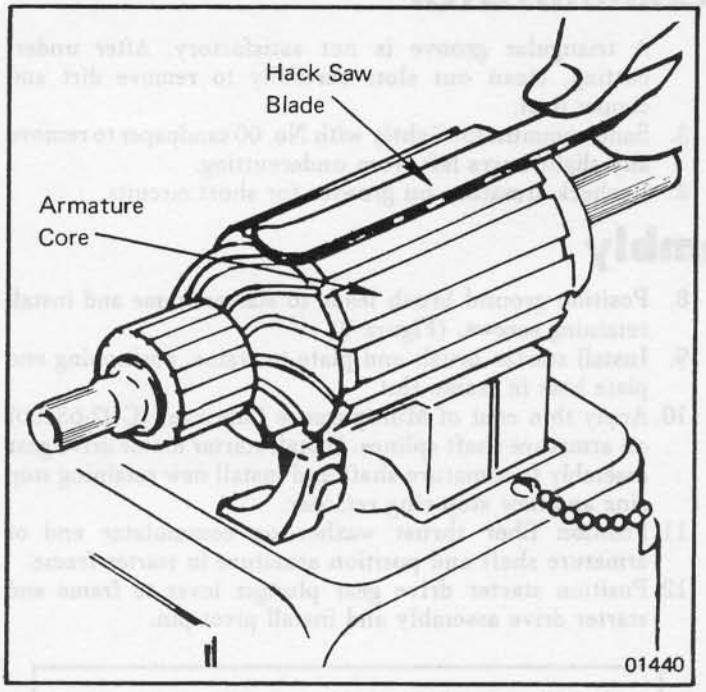


Figure 5. Armature Test for Shorts

ARMATURE TEST for GROUND

1. With continuity meter or lamp, place one lead on armature core or shaft and other lead on commutator.
2. If meter hand moves to right or lamp lights, armature is grounded and must be replaced. (Figure 6)

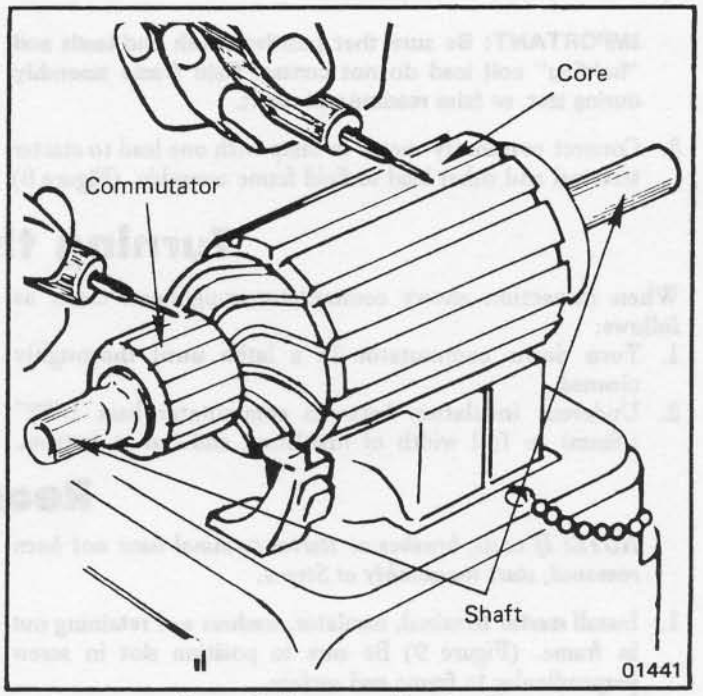


Figure 6. Armature Test for Ground

FIELD COIL

FIELD COIL TEST for OPEN CIRCUIT

1. Insulate starter contacts with non-conductive material. (Figure 8)
2. With continuity meter or lamp, place one lead on starter terminal and other lead to one positive (insulated) brush. (Figure 7)
3. If meter hand does not move to right or lamp does not light, field coils are open and must be replaced.

FIELD COIL TEST for GROUND

1. Disconnect "holding" coil ground lead. (Figure 8)
2. Insulate starter contacts with non-conductive material. (Figure 8)

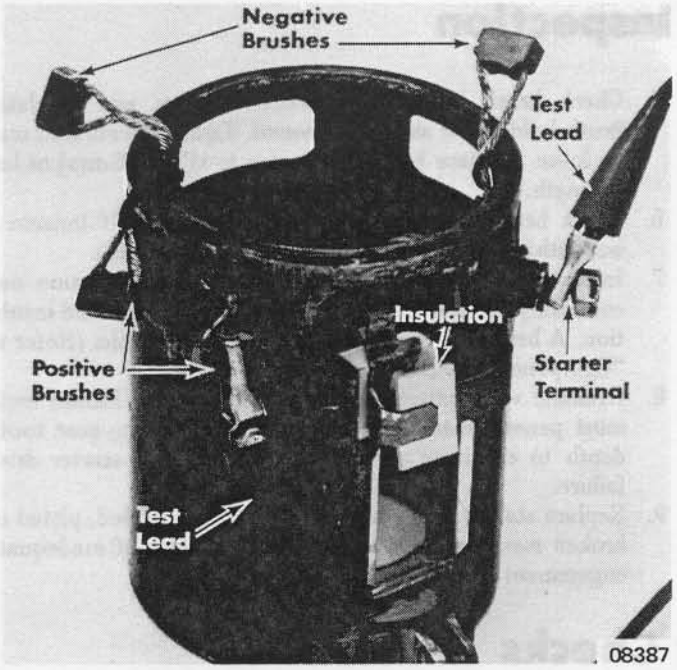


Figure 7. Field Coil Test for Open Circuit

IMPORTANT: Be sure that positive brush and leads and "holding" coil lead do not contact field frame assembly during test, or false reading will result.

3. Connect continuity meter or lamp with one lead to starter terminal and other lead to field frame assembly. (Figure 8)
4. If meter hand moves to right or lamp lights, field coils are grounded and require replacement.

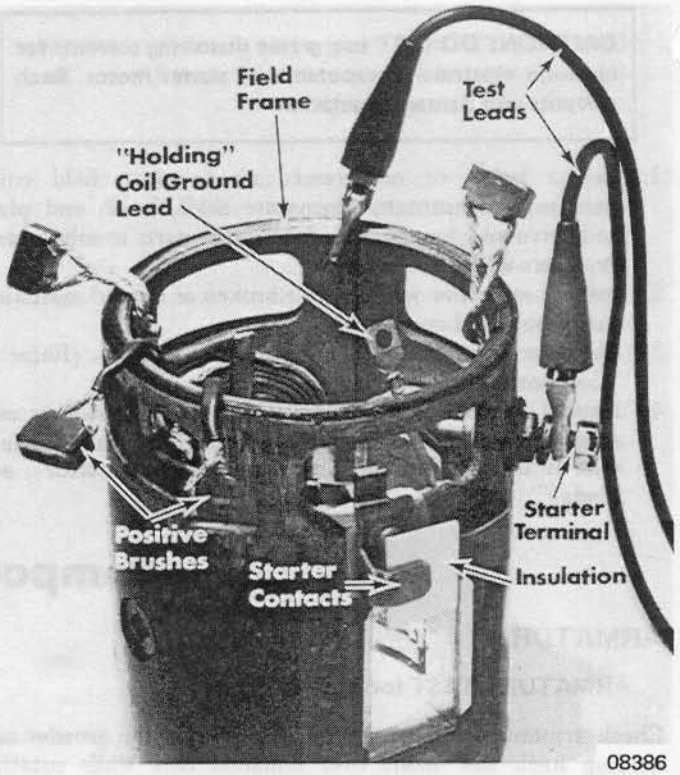


Figure 8. Field Coil Test for Ground

Turning the Commutator

When inspection shows commutator roughness, clean as follows:

1. Turn down commutator in a lathe until thoroughly cleaned.
2. Undercut insulation between commutator bars 1/32" (.8mm) to full width of insulation and flat at bottom. A triangular groove is not satisfactory. After undercutting, clean out slots carefully to remove dirt and copper dust.
3. Sand commutator lightly with No. 00 sandpaper to remove any slight burrs left from undercutting.
4. Recheck armature on growler for short circuits.

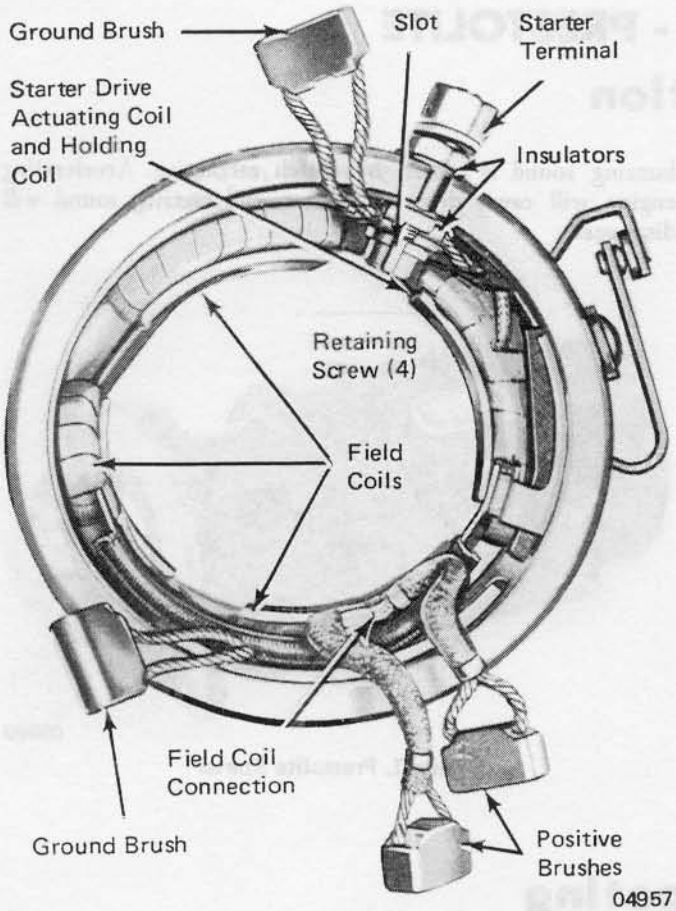
Reassembly

NOTE: If coils, brushes or starter terminal have not been removed, start reassembly at Step 9.

1. Install starter terminal, insulator, washers and retaining nut in frame. (Figure 9) Be sure to position slot in screw perpendicular to frame end surface.
2. Position coils and pole pieces with coil leads in terminal screw slot, then install retaining screws. (Figure 9) As pole shoe screws are tightened, strike frame several sharp blows with a soft-faced hammer to seat and align pole shoes, then stake the screws.
3. Install starter drive actuating coil and holding coil and retainer and bend tabs to hold coils to frame.
4. Solder the field coils and solenoid wire to starter terminal, using rosin core solder. Use a 300-watt iron.
5. Check for continuity and grounds in assembled coils. Refer to "Component Checks". (See Index)
6. Position new insulated field brushes lead on field coil terminal. Install clip (provided with brushes) to hold brush lead to terminal. Solder the lead, clip and terminal together, using rosin core solder. (Figure 9) Use a 300-watt iron.
7. Position holding coil ground terminal over nearest ground screw hole.
8. Position ground brush leads to starter frame and install retaining screws. (Figure 9)
9. Install starter brush end plate to frame, positioning end plate boss in frame slot.
10. Apply thin coat of Multipurpose Lubricant (C-92-63250) on armature shaft splines. Install starter motor drive gear assembly to armature shaft and install new retaining stop ring and new stop ring retainer.
11. Position fiber thrust washer on commutator end of armature shaft and position armature in starter frame.
12. Position starter drive gear plunger lever to frame and starter drive assembly and install pivot pin.

CAUTION: DO NOT pinch brush leads between brush plate and frame. Be sure that stop ring retainer is seated properly in drive housing.

13. Position starter drive plunger lever return spring and drive end housing to frame and install and tighten thru bolts to specification (55-75 in. lbs. [63-86kg-cm]).
14. Install brushes in brush holders. Be sure to center brush springs on brushes.



15. Position drive gear plunger lever cover on starter and install brush cover band with gasket. Tighten band retaining screw.
16. Check starter no-load current draw. Current should be 50 to 100 amps.

Figure 9. Field Coil Assembly

Installation

1. Position starter assembly to flywheel housing and start mounting bolts.
2. Snug all bolts while holding starter squarely against its mounting surface and fully inserted into pilot hole. Torque bolts to specification.
3. Connect electrical wire to starter.
4. Connect battery cables to battery.

STARTER MOTOR - PRESTOLITE

Description

This starter motor uses a Bendix Folo-Thru type drive that is designed to overcome premature de-meshing of drive pinion until predetermined engine speed is reached.

When pinion is engaged with flywheel ring gear, a spring-loaded detent pin (located in pinion gear assembly) engages with notch in screw shaft. If engine fails to continue running, movement of pinion in de-meshing direction is checked by pin engagement in screw shaft. Pinion then remains locked in engaged position until engine operates at predetermined speed, at which time centrifugal action forces detent pin out of notch in screw shaft and allows pinion to de-mesh from flywheel. Thus, if engine starts and fails to continue running, pinion gear remains engaged with flywheel ring gear. For this reason, if starting motor is re-engaged while engine is rocking back, no damage will occur.

If engine should start, but not reach speed high enough to disengage detent pin, a ratchet type clutch on screw shaft allows pinion to over-run armature shaft. This serves as a safety factor, thus preventing damage to starting motor. When this occurs, a light buzzing sound is sometimes heard. This buzzing sound is caused by clutch ratcheting. Accelerating engine will cause drive to release, and buzzing sound will disappear.

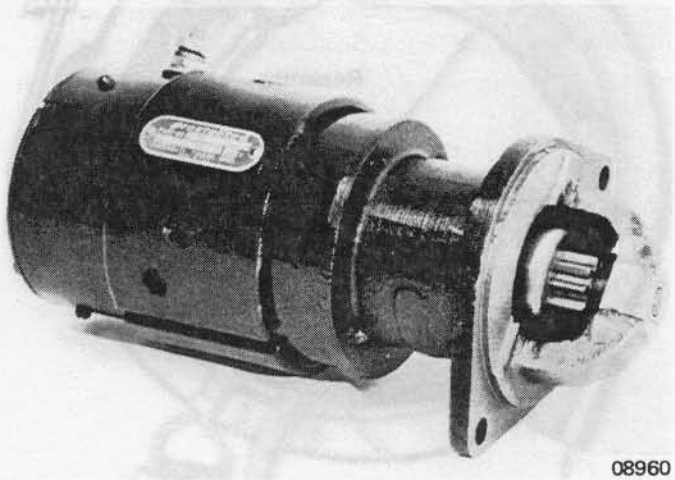


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Figure 1. Prestolite Starter

Troubleshooting

Refer to "Cranking Circuit Malfunctions - Autolite and Prestolite" in "Troubleshooting" Section 10.

Removal

1. Disconnect battery cables from battery.
2. Disconnect starter cable at starter terminal and ground cable from starter mounting stud. (Figure 2)
3. Remove starter mounting bolts. (Figure 2)
4. Remove starter from engine.

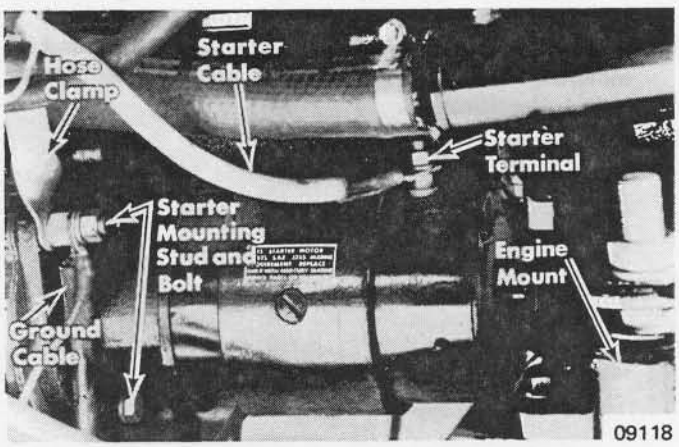

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Figure 2. Prestolite Starter Installed - Typical

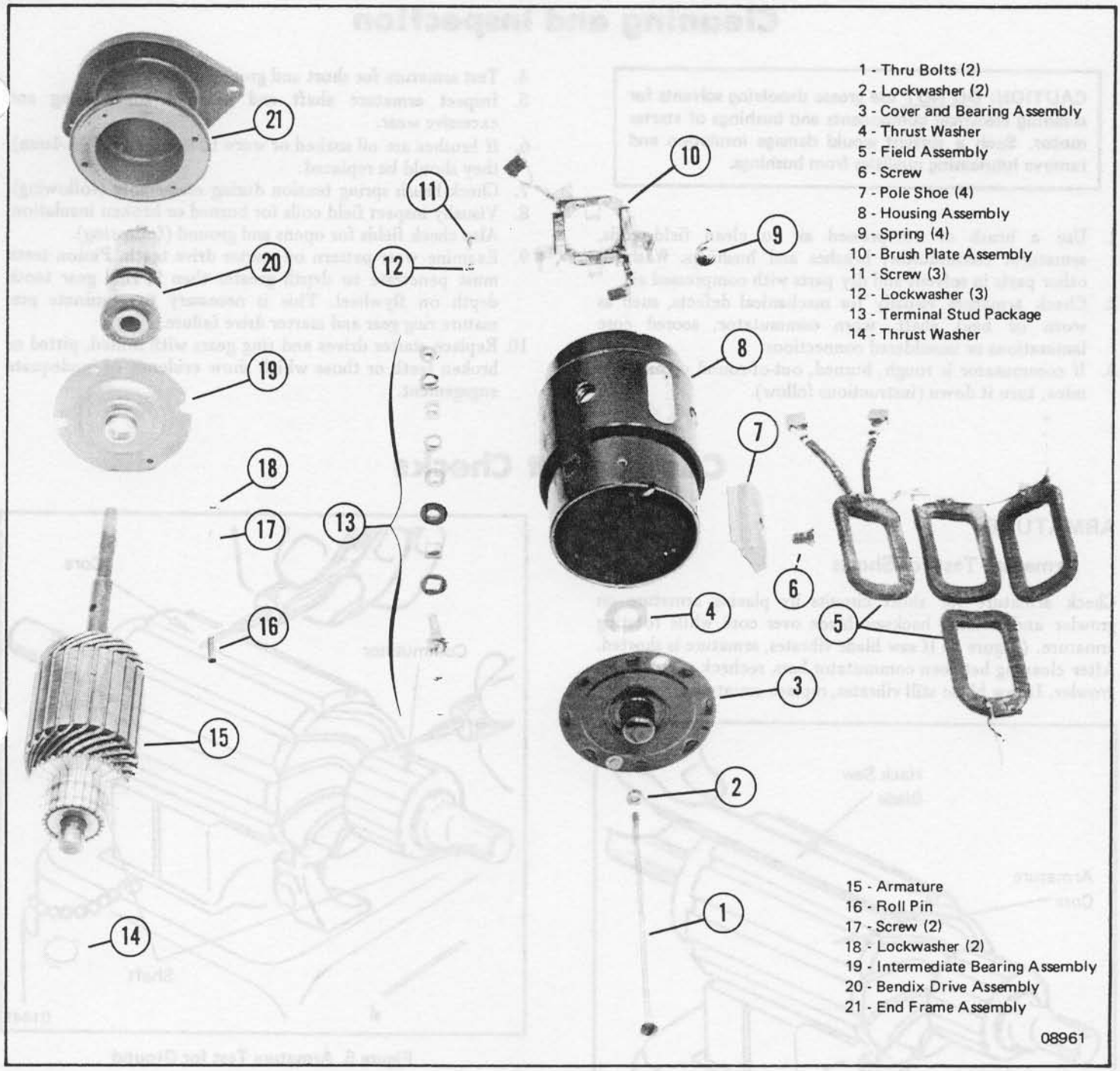


Figure 3. Prestolite Starter Parts Identification

Disassembly

NOTE: Refer to Figure 3 for parts identification.

1. Remove 2 thru bolts and cover assembly from commutator end of starter motor.
2. Remove starter housing from armature and end frame assembly.
3. Remove 2 screws, which hold intermediate bearing assembly to end frame assembly, and remove end frame assembly.
4. Remove pin and bendix drive assembly and intermediate bearing assembly from armature shaft.

NOTE: DO NOT perform following Steps 5, 6 and 7, unless replacement of those parts is necessary.

5. Remove 3 screws and brush plate assembly. Springs and brushes may be removed if needed.
6. Disconnect field wire from terminal stud and remove 4 screws, field assembly and pole shoes.
7. Remove nuts and remove terminal stud package.

Cleaning and Inspection

CAUTION: DO NOT use grease dissolving solvents for cleaning electrical components and bushings of starter motor. Such a solvent would damage insulation and remove lubricating qualities from bushings.

1. Use a brush or compressed air to clean field coils, armature, commutator, brushes and bushings. Wash all other parts in solvent and dry parts with compressed air.
2. Check armature visually for mechanical defects, such as worn or bent shaft, worn commutator, scored core laminations or unsoldered connections.
3. If commutator is rough, burned, out-of-round or has high mica, turn it down (instructions follow).
4. Test armature for short and ground (following).
5. Inspect armature shaft and bearings for scoring and excessive wear.
6. If brushes are oil soaked or worn to less than ¼" (6.4mm), they should be replaced.
7. Check brush spring tension during reassembly (following).
8. Visually inspect field coils for burned or broken insulation. Also check fields for opens and ground (following).
9. Examine wear pattern on starter drive teeth. Pinion teeth must penetrate to depth greater than ½ ring gear tooth depth on flywheel. This is necessary to eliminate premature ring gear and starter drive failure.
10. Replace starter drives and ring gears with milled, pitted or broken teeth or those which show evidence of inadequate engagement.

Component Checks

ARMATURE

Armature Test for Shorts

Check armature for short circuits by placing armature on growler and holding hacksaw blade over core while rotating armature. (Figure 4) If saw blade vibrates, armature is shorted. After cleaning between commutator bars, recheck armature on growler. If saw blade still vibrates, replace armature.

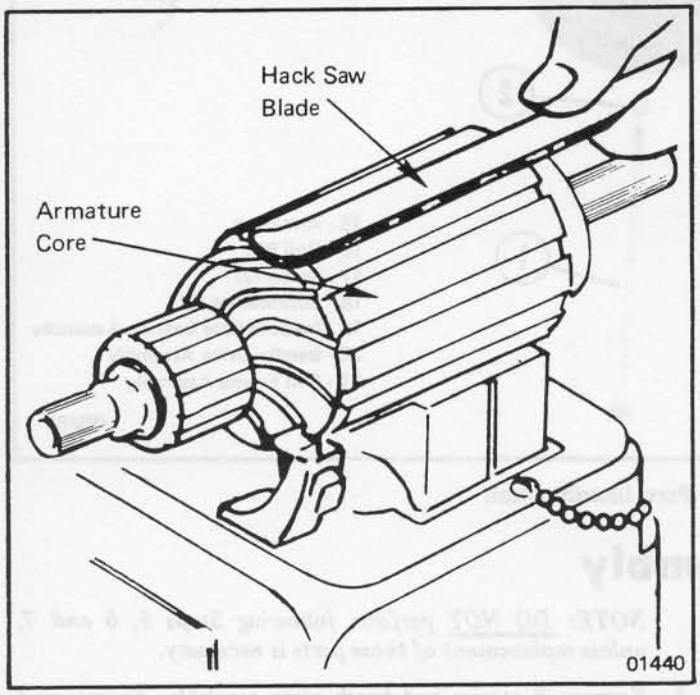


Figure 4. Armature Test for Shorts

Armature Test for Ground

1. With continuity meter or test lamp, place one lead on armature core or shaft and other lead alternately on commutator segments.
2. If meter indicates continuity or lamp lights, armature is grounded and must be replaced. (Figure 5)

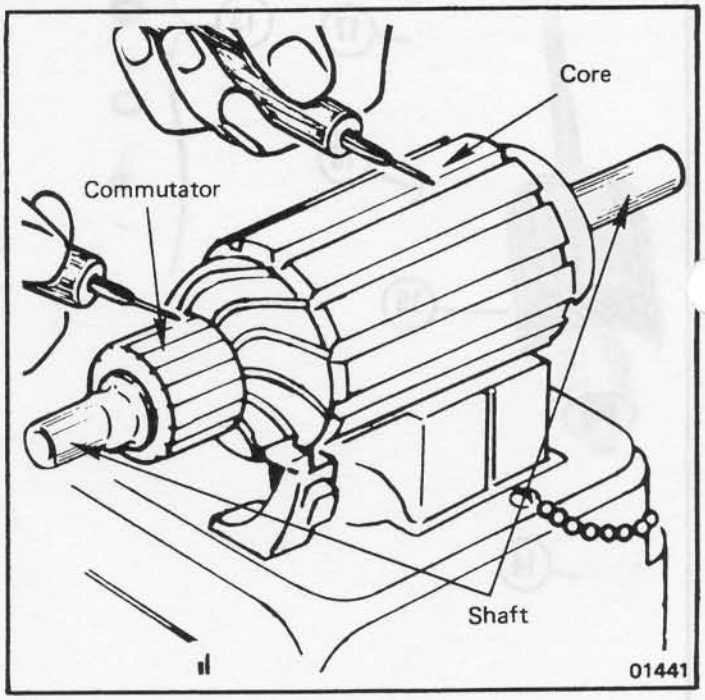


Figure 5. Armature Test for Ground

FIELD COIL

Field Coil Test for Open Circuit

With continuity meter or test lamp, place one lead on starter terminal and other lead to positive (insulated) brush. (Figure 6) If meter does not indicate continuity or lamp does not light, field coils are open and must be replaced.

Field Coil Test for Ground

1. Disconnect shunt field wire from brush holder if holder is still installed.

IMPORTANT: Take care that positive brushes, brush leads and shunt field wire do not contact starter housing assembly during test, or false reading would result.

2. Connect continuity meter or test lamp with one lead to starter terminal and other lead to starter housing. (Figure 7) If meter indicates continuity or lamp lights, field coils are grounded and need replacement.

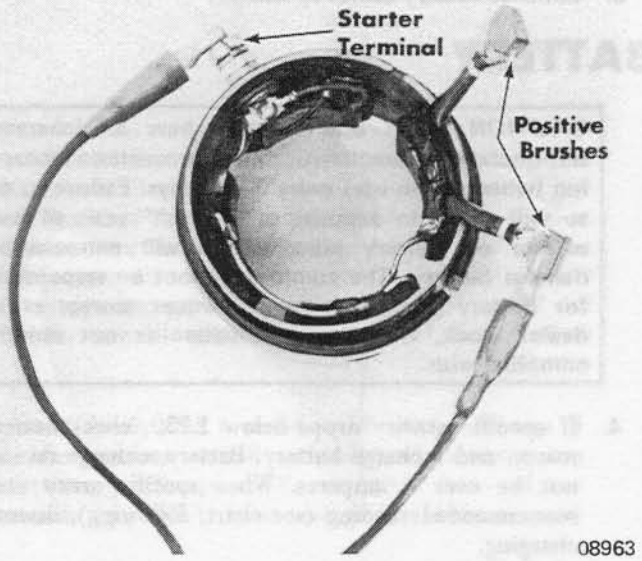


Figure 6. Field Coil Test for Open Circuit

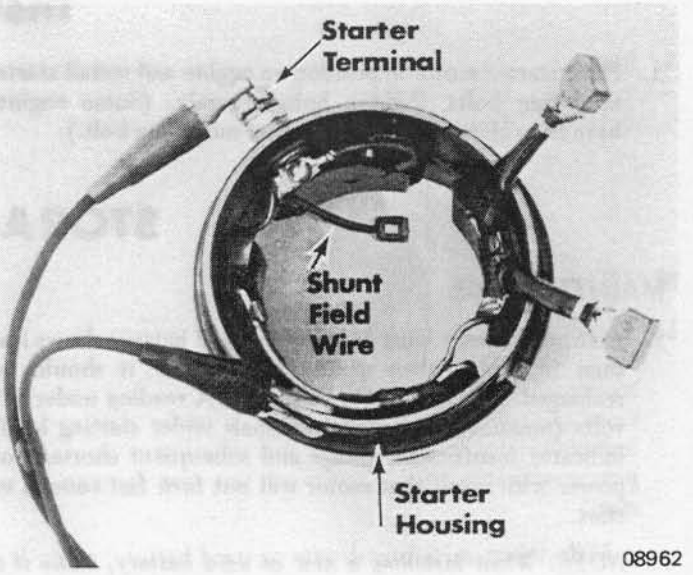


Figure 7. Field Coil Test for Ground

TURNING the COMMUTATOR

Follow same procedure as outlined in Delco-Remy starter, preceding (use "Index").

Lubrication

Periodic lubrication of starting motor is not required; however, during reassembly of starter motor (especially if parts have been cleaned), bearings should be soaked in SAE 10 oil. Also, lubricate drive end of armature shaft sparingly with a film of SAE 10 oil.

Reassembly

NOTE: If brush plate assembly, field windings and terminal stud package have not been removed, start reassembly at Step 4.

1. Install terminal stud package in sequence shown in Figure 3. Check with continuity meter to be sure that stud is insulated from starter housing.
2. Place field windings and pole shoes in starter housing. Install 4 screws thru starter housing and into poles. Tighten screws securely.
3. Place brush plate assembly in position and install 3 screws and lockwashers thru starter housing and into plate assembly. Tighten screws securely. Install shunt ground wire to brush plate assembly. Install brush springs (if removed).
4. Lubricate bearing surface of intermediate bearing assembly and install assembly on armature shaft. Lubricate drive end of armature shaft sparingly with a film of SAE 10 oil. Place bendix drive assembly on shaft and install roll pin.
5. Lubricate bearing (located in end frame assembly) and install armature assembly into end frame. Install 2 screws and lockwashers thru intermediate bearing assembly and into end frame. Tighten screws securely.
6. Position armature assembly in starter housing.
7. Place proper thickness of thrust washer on armature shaft so that shaft end play is at .005" to .030" (.13 to .76mm).
8. Check brush spring tension. Measure with scale hooked under brush spring near brush. Pull on line parallel to face of brush and take reading just as spring leaves brush. Tension must be within specifications (Section 8).
9. Lubricate bearing in cover assembly and position cover on armature shaft and starter housing. Insert thru bolts and tighten bolts securely.
10. Check armature shaft end play. Clamp starter motor in vise with dial gauge on end of armature shaft. Move shaft to one end of starter housing. Zero dial indicator. Move shaft to other end of housing. End play should be between .005" to .030". To correct end play, use different thickness thrust washer on armature shaft.
11. Check clearance between cover and bearing assembly (Item 3 in Figure 3) and housing assembly (Item 8). Clearance should not exceed .012" (.305mm) on Prestolite starters. If found excessive, check seating of cover onto housing. If properly seated, and excessive gap remains, replace cover.

Installation

1. Place starter motor in position on engine and install starter mounting bolts. Tighten bolts securely. (Some engines have hose clamp attached to starter mounting bolt.)
2. Connect battery ground cable to starter mounting bolt and yellow cable from starter solenoid to starter terminal. (Figure 2)
3. Connect battery cables to battery.

STORAGE BATTERY

MAINTENANCE

1. A strong battery must be maintained. If battery shows less than 9½ volts when under starting load, it should be recharged. Check with DC voltmeter. A reading under 9½ volts (measured at battery terminals under starting load) indicates insufficient voltage and subsequent shortage of power with result that motor will not turn fast enough to start.

   NOTE: When installing a new or used battery, make it a habit to wire brush tapered terminals and clamp terminals, then clean and grease them. This will protect against high resistance connections which make it difficult to keep battery fully charged and may contribute to low available voltage in entire electrical starting system (and ignition system).

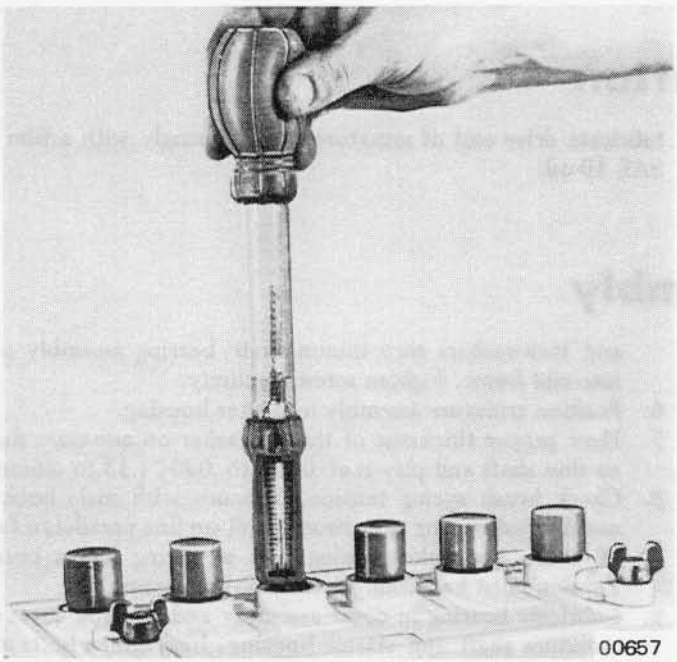


Figure 1. Testing with Hydrometer

2. A 12-volt, full marine-type battery of a minimum 70-ampere-hour capacity, with Reserve Capacity Rating of 100 minutes, is recommended for all MerCruiser engines.

   NOTE: Check also can be made with hydrometer. (Figure 1) If reading is below 1.230 (specific gravity), recharge or replace present battery. See Section 10, "Troubleshooting", for battery testing procedure.

3. When adding distilled water to battery, be extremely careful not to fill more than 3/16" (4.8mm) above perforated baffles inside battery. Battery solution or electrolyte expands from heat caused by charging. Overfilling battery will cause electrolyte to overflow, if filled beyond 3/16" above baffles.

CAUTION: Lead acid batteries have an inherent, self-discharge characteristic which necessitates recharging (when not in use) every 30-45 days. Failure to do so will result in deposits of "whitish" scale of lead sulfate on battery plates which will permanently damage battery. The company cannot be responsible for battery damage, either in winter storage or in dealer stock, if above information is not strictly complied with.

4. If specific gravity drops below 1.230, check battery for reason and recharge battery. Battery recharge rate should not be over 4 amperes. When specific gravity reaches recommended reading (see chart, following), discontinue charging.

AMPERE CAPACITY

1. New storage batteries, which are not initially fully charged, supply insufficient amperage and voltage capacity to starting (cranking) motor and results in few engine starts before battery no longer turns starter motor fast enough to start engine.
2. A dry-charge battery should not be filled with electrolyte until sold. After battery has been filled, wait 15 minutes and check specific gravity of each cell with a hydrometer. If specific gravity drops below 1.230 in any cell, bring battery up to full charge before placing in service. Bring battery to full charge with a slow charge for 2-to-3 hours at 5-6 ampere rate.

TABLE of GRAVITY READINGS

1. Specific gravity of electrolyte in a charged battery, which contains approximately 39 percent sulphuric acid, is 1.290. Specific gravity of a discharged battery, which contains approximately 14 percent acid, is 1.100. Specific gravity readings between these 2 extremes indicate various states of battery charge. Refer to following tabulation which translates specific gravity into general terms of battery state of charge. Table is based on battery's ability to crank engine at 80°F. It is assumed that no electrolyte has been lost from the battery and that adjustment at full charge is correct.

Capacity Reading*	Battery Condition
1.260 Sp. Gr.	100% Charged
1.230 Sp. Gr.	75% Charged
1.200 Sp. Gr.	50% Charged
1.170 Sp. Gr.	25% Charged
1.140 Sp. Gr.	Very Little Useful Capacity
1.110 Sp. Gr.	Discharged

* *Based on a temperature of 80° F (27° C)*

2. To obtain accurate measurements of battery's state of charge, consider temperature as well as the specific gravity. Specific gravity of electrolyte varies not only with amount of sulphuric acid in solution, but also with temperature of solution. As electrolyte is cooled, it contracts, becoming more dense and gaining specific gravity. When electrolyte is heated, it expands, becoming less dense and losing in specific gravity.

Battery Charging Guide (6-Volt and 12-Volt Batteries)

Recommended Rate* and Time for Fully Discharged Condition

Twenty Hour Rating	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes	50 Amperes
50 Ampere-Hours or Less	10 Hours	5 Hours	2-1/2 Hours	2 Hours		
Above 50 to 75 Ampere-Hours	15 Hours	7-1/2 Hours	3-1/4 Hours	2-1/2 Hours	2 Hours	1-1/2 Hours
Above 75 to 100 Ampere-Hours	20 Hours	10 Hours	5 Hours	3 Hours	2-1/2 Hours	2 Hours
Above 100 to 150 Ampere-Hours	30 Hours	15 Hours	7-1/2 Hours	5 Hours	3-1/2 Hours	3 Hours
Above 150 Ampere-Hours		20 Hours	10 Hours	6-1/2 Hours	5 Hours	4 Hours

** Initial rate for constant voltage taper rate charger*

To avoid damage, charging rate must be reduced or temporarily halted, if:

1. Electrolyte temperature exceeds 125° F (52° C).

2. Violent gassing or spewing of electrolyte occurs.

Battery is fully charged when, over a two hour period at a low charging rate in amperes, all cells are gassing freely and no change in specific gravity occurs. For the most satisfactory charging, the lower charging rates in amperes are recommended.

Full charge specific gravity is 1.260-1.280, corrected for temperature with electrolyte level at split ring.

Winter Storage of Batteries

Battery companies are not responsible for battery damage either in winter storage or in dealer stock if the following instructions are not complied with:

1. Remove battery from its installation as soon as possible and remove all grease, sulfate and dirt from top surface by running water over top of battery. Be sure, however, that vent caps are tight beforehand, and blow off all excess water thoroughly with compressed air. Check water level, making sure that plates are covered.
2. When adding distilled water to battery, be extremely careful not to fill more than 3/16" (4.8mm) above perforated baffles inside battery. Battery solution or electrolyte expands from heat caused by charging. Over-filling battery will cause electrolyte to overflow (if filled beyond 3/16" above baffles).
3. Grease terminal bolts well with Multipurpose Lubricant (C-92-63250) and store battery in COOL-DRY place. Remove battery from storage every 30-45 days, check water level and put on charge for 5 or 6 hours at 6 amperes. DO NOT FAST CHARGE.
4. If specific gravity drops below 1.240, check battery for reason and recharge. When gravity reaches 1.260, discontinue charging. To check specific gravity, use a hydrometer, which can be purchased locally. (Figure 1)
5. Repeat preceding charging procedure every 30-45 days, as long as battery is in storage, for best possible maintenance during inactive periods to ensure a good serviceable battery in spring. When ready to place battery back in service, remove excess grease from terminals (a small amount is desireable on terminals at all times), recharge again as necessary and reinstall battery.

When charging 2 or more batteries, connect them in series, positive (+) terminal of one to negative (-) terminal of next.

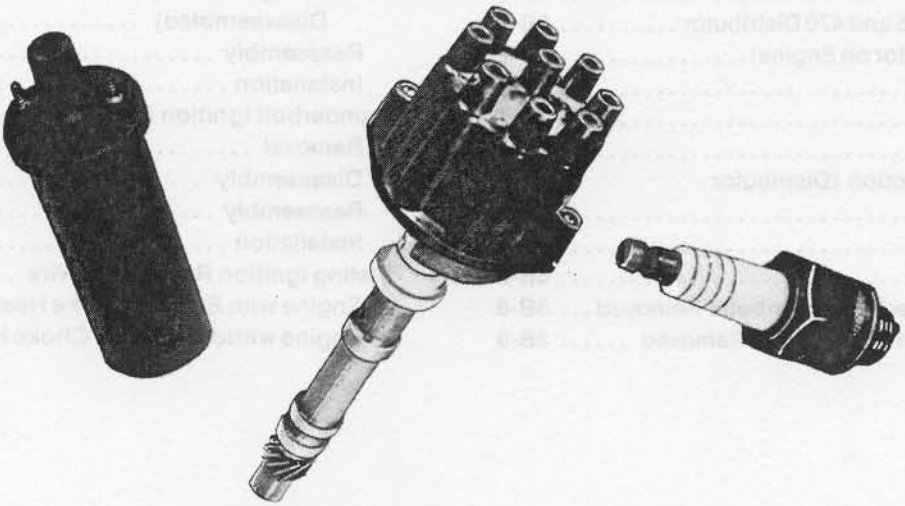
SAFETY WARNING: Hydrogen and oxygen gases are produced during normal battery operation or charging. Sparks or flame can cause this mixture to ignite and explode, if they are brought near the vent openings. Sulphuric acid in battery can cause serious burns, if spilled on skin or in eyes. Flush or wash away immediately with clear water.

Battery Charging Guide
(6-Volt and 12-Volt Batteries)

Hourly Rate	5 Amperes	10 Amperes	20 Amperes	30 Amperes	40 Amperes
60 Ampere-Hours or Less	10 Hours	5 Hours	2-1/2 Hours	2 Hours	
Above 60 to 75 Ampere-Hours	15 Hours	7-1/2 Hours	3-1/4 Hours	2-1/2 Hours	2 Hours
Above 75 to 100 Ampere-Hours	20 Hours	10 Hours	5 Hours	3 Hours	2-1/2 Hours
Above 100 to 150 Ampere-Hours	30 Hours	15 Hours	7-1/2 Hours	5 Hours	3-1/2 Hours
Above 150 Ampere-Hours		20 Hours	10 Hours	6-1/2 Hours	5 Hours

SECTION 3 - ELECTRICAL SYSTEM

PART B - IGNITION SYSTEM



MERCURY MARINE

A BRUNSWICK COMPANY

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IGNITION SYSTEM

Components

The breaker point ignition system consists of a distributor (including breaker points and condenser), ignition coil, ignition switch, battery, spark plugs and resistor wire. The Thunderbolt Ignition System consists of a distributor (including trigger assembly), ignition coil, switch box assembly, ignition switch, battery and spark plugs.

Precautions

SAFETY WARNING: When testing or servicing the ignition system, it is of extreme importance that the following precautions be observed, as high voltage is present. DO NOT touch or disconnect any ignition system parts while engine is running, key switch is on, or while battery cables are connected. Follow test procedures carefully.

Failure to comply with the following may result in damage to the ignition system.

1. Do not reverse battery cable connections at the battery. System is negative (-) ground.
2. Do not "spark" battery terminals with battery cable connectors to check polarity.
3. Do not disconnect battery cables while engine is running.
4. Use only test equipment as specified when testing Thunderbolt Ignition. System cannot be checked with conventional ignition test equipment.
5. Follow service procedures in the order listed in the following information.

Ignition Contact Points

CRITERIA for REPLACING POINTS

1. Examine distributor points. Dirty points should be cleaned with clean point file. Normal point condition is overall grey color.
2. If test instrument for checking resistance is available, check point resistance.
3. Criteria for point quality should be combination of visual inspection and resistance or voltage drop check.
4. Replace badly worn, pitted or misaligned points.
5. If (with points closed and ignition switch in "On" position) less than 0.125 volt drop exists across points, points are satisfactory. Make this check with a sensitive voltmeter or a point resistance meter.

ABNORMAL POINT WEAR

1. Under normal operating conditions, distributor contact points will provide many hours of service.
2. Points, which have been operated for a period of time, have a rough surface, but this may not mean that points are worn out.
3. If points burn or pit, however, they soon become unsatisfactory for further operation. Not only must they be replaced, but ignition system and engine must be checked to determine cause and elimination of trouble. Unless condition, which causes point burning or pitting is corrected, new points will provide no better service than old points.

BURNING of POINTS

1. Contact point burning results from high voltage, presence of oil or other foreign material, defective condenser and improper point adjustment.
2. High voltage causes excessively high current flow thru contact points which burns them rapidly. High voltage can result from improperly adjusted or inoperative voltage regulator.
3. Oil or crankcase vapors, which work up into distributor and deposit on point surfaces, cause them to burn rapidly. This is easy to detect, since oil produces a smudgy line under contact points. Clogged engine breather pipes permit crankcase pressure to force oil or vapors up into distributor. Over-oiling distributor also produces the condition.
4. If contact point opening is too small (cam angle too large), points will be closed too large a part of total operating time. Average current flow thru points will be too high, so points will burn rapidly and arcing will occur between points and result in low secondary voltage and engine miss.
5. High series resistance in condenser circuit will prevent normal condenser action, so contact points will burn rapidly. This resistance may be caused by a loose condenser mounting or lead connection, or by poor connections inside condenser. See "Distributor Condenser", following, for a discussion of condenser testing.

PITTING of POINTS

1. Contact point pitting results from an out-of-balance condition in ignition system which causes transfer of material from one point to other so that a tip builds up on one point while a pit forms in other. (Figure 1)

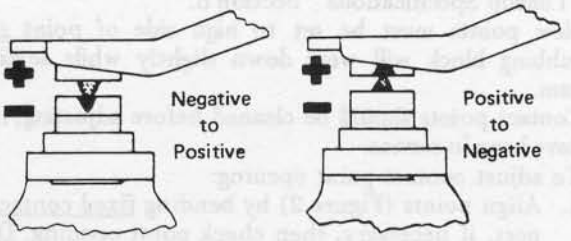

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Figure 1. Material Transfer

2. Direction, in which material transfers, can be used as a basis for analysis and correction of pitting. For example, if material transfers from negative to positive point (Figure 1), one or more of these corrections may be made. Increase condenser capacity, shorten condenser lead, separate distributor-to-coil low and high-tension leads or move these leads closer to ground.
3. If material transfers from positive to negative point, reduce condenser capacity, move distributor-to-coil leads closer together, move these leads away from ground or lengthen condenser lead.

CLEANING of POINTS

1. Dirty contact points should be dressed with a few strokes of a clean, fine-cut contact file. File should not be used on other metals and should not be allowed to become greasy or dirty.

   NOTE: Never use emery cloth to clean contact points.

2. Contact surfaces, after considerable use, may not appear bright and smooth, but this is not necessarily an indication that they are not functioning satisfactorily. Do not attempt to remove all roughness nor dress point surfaces down smooth. Merely remove scale or dirt.
3. Badly burned or pitted contact points should be replaced and cause of trouble determined and corrected.

Contact Point Replacement

1. Release distributor cap hold-down screws, remove cap and place it out of work area.
2. Remove rotor.
3. (Prestolite only): Remove 2 screws from breaker plate and remove plate from housing. (Figure 3 on Page 3B-14)
4. Remove primary and condenser lead wires from contact point terminal (Mercury) or primary terminal screw (Prestolite and Mallory).
5. Remove contact set attaching screw and lift contact point set from breaker plate.
6. Clean oil smudge and dirt from breaker plate.

CAUTION: Carefully wipe protective film from point set prior to installation.

7. Place new contact point assembly in position on breaker plate and install attaching screw.

   NOTE: (Mercury only) Pilot on contact set must engage matching hole in breaker plate.

8. Connect primary and condenser lead wires to terminal on contact point set (Mercury) or primary terminal screw (Prestolite and Mallory).
9. Check and adjust points for proper alignment and breaker arm spring tension. Use an aligning tool to bend stationary contact support, if points need alignment.

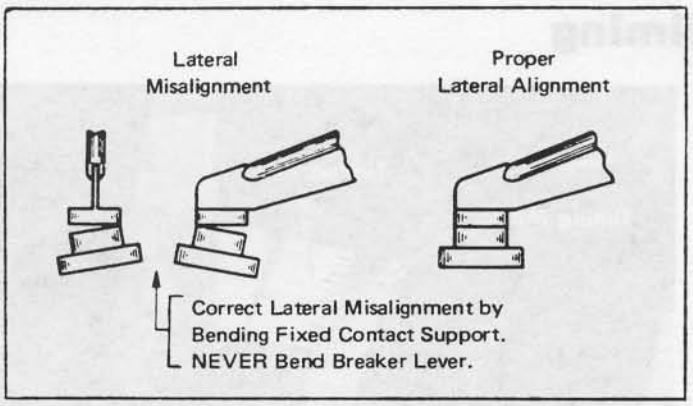
   NOTE: Contact point pressure must fall within specified limits (see "Specifications" Section 8). Weak tension will cause chatter which results in arcing and burning of points and an ignition miss at high speed, while excessive tension will cause undue wear of contact points, cam and rubbing block. Contact point pressure should be checked with a spring gauge. Scale should be hooked to breaker lever and pull exerted at 90° to breaker lever. Reading should be taken just as points separate. Pressure can be adjusted by bending breaker lever spring. If pressure is excessive, it can be decreased by pinching spring carefully. To increase pressure, remove lever from distributor so that spring can be bent away from lever. Avoid excessive spring distortion.

10. Set point opening; see "Tuneup Specifications" Section 8.
11. Reinstall rotor and position and lock distributor cap to housing.
12. Use dwell meter to recheck dwell.
13. Check and set ignition timing.

Setting and Alignment of Points

1. Contact points must be set with a feeler gauge to proper opening. Points set too close may burn and pit rapidly. Points with excessive separation cause a weak spark at high speed.
2. Proper point settings for all models are listed under "Tuneup Specifications" Section 8.
3. New points must be set to high side of point gap, as rubbing block will wear down slightly while seating to cam.
4. Contact points should be cleaned before adjusting, if they have been in service.
5. To adjust contact point opening:
   a. Align points (Figure 2) by bending fixed contact support, if necessary, then check point opening. Do not bend breaker lever. Make adjustment by bending fixed contact support only.
      Align new points but do not attempt to align used points. Instead, replace used points where serious misalignment is observed. Use an aligning tool, if available.
   b. Turn or crank distributor shaft until breaker arm rubbing block is on extreme top of a lobe of cam which will provide maximum breaker point opening.
   c. Loosen breaker point retaining screw(s).
   d. Use adjusting slots or turn eccentric adjusting screw clockwise or counterclockwise to obtain correct opening for points. See "Tuneup Specifications" Section 8.
   e. Tighten retaining screw(s) and recheck point opening.
   f. After checking and adjusting contact point opening to specifications, cam angle or dwell should be checked with a contact angle (dwell) meter.

      If cam angle is less than specified minimum, check for defective or misaligned contact points or worn distributor cam lobes. Variation in cam angle readings between idle



speed and 1750 engine RPM should not exceed 3°. Excessive variation in this speed range indicates wear in distributor.

NOTE: Cam angle readings, taken at speeds above 1750 engine RPM, may prove unreliable on some cam angle meters.

Figure 2. Alignment of Points

Spark Plugs

INSPECTION

1. Inspect each plug individually every 100 hours for badly worn electrodes, glazed, broken or blistered porcelain and replace where necessary.

   NOTE: Spark plugs should be replaced after 200 hours of operation.

2. Inspect each spark plug for make and heat range. All plugs must be the same make and number or heat range. Refer to "Specifications" Section 8 for spark plug numbers.

CAUTION: Never bend the center electrode to adjust gap. Always adjust by bending ground or side electrode.

3. Adjust spark plug gaps with a round feeler gauge. (Figure 3) Refer to "Specifications" Section 8 for spark plug gap.
4. Clean spark plug seating area and install new gaskets on flat-seat plugs. DO NOT re-use gaskets, and DO NOT use gaskets on taper seat plugs. Install spark plugs and torque to specifications listed in Section 8. Where used, gasket must be fully compressed to complete heat transfer and provide a gas-tight seal in cylinder. For this reason, as well as necessity of maintaining correct plug gap, correct torque is very important during installation.

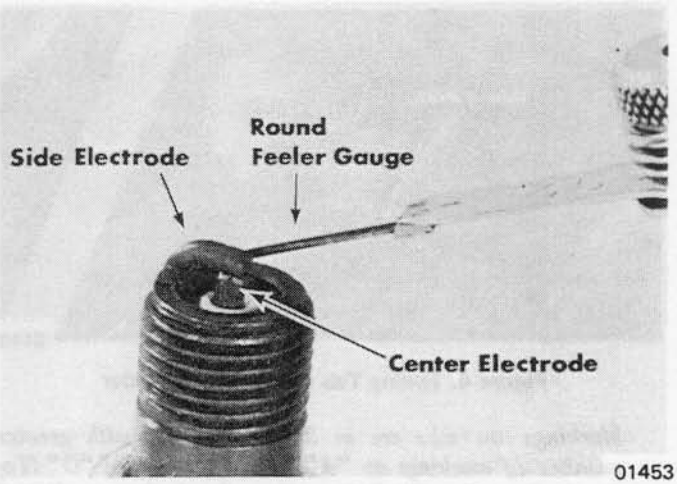


Figure 3. Adjusting Gap

5. Replace or repair any loose or damaged spark plug wires. Install all wires to proper spark plug. Proper positioning of spark plug wires in supports is important to prevent cross-firing.

CAUTION: Tapered seat spark plugs are not interchangeable with nontapered (with gasket) spark plugs. Refer to "Specifications" Section 8 for recommendations.

Coil and Resistor Wire Checks

NOTE: Use Magneto Analyzer (C-91-25213 or C-91-31800) and follow instruction manual included with analyzer. Use specifications listed in Section 8, "Specifications".

1. Check coil for the following:
   a. Coil power test
   b. Coil surface insulation test
   c. Coil continuity test
   d. Primary resistance test
2. Check resistor wire for ohms reading as listed in "Specifications" Section 8. (Test instructions follow; use "Index".)
3. Replace coil and/or resistor wire if test results are not within specifications.

Distributor Condenser Checks

NOTE: Use Magneto Analyzer (C-91-25213 or C-91-31800) and follow instruction manual included with analyzer. Use specifications listed in Section 8, "Specifications".

1. Test condenser for the following:
   a. Condenser capacity test
   b. Condenser leakage and short test
   c. Condenser series resistance test
2. Replace condenser if test results are not within specifications.

Ignition Timing

TIMING MARK LOCATION

The timing marks and their locations are illustrated in Figures 4-thru-6, following.

TIMING MERCRUISER ENGINES

1. Connect timing light to No. 1 spark plug lead, at or near plug. Connect power supply leads on light to battery (12 volts). Refer to "Specifications" Section 8 for cylinder numbering and location.
2. Connect tachometer to engine.
3. Start engine and run at normal idle speed.
4. Aim timing light at timing tab, located on timing gear cover and crankshaft harmonic balancer.

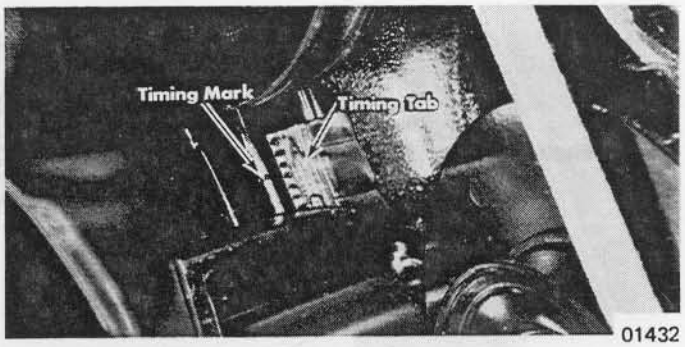


Figure 4. Timing Tab on 4 and 6-Cylinder

Markings on tabs are in 2° increments, with greatest number of markings on "A" (Advance) side of "O" (Top Dead Center). All Before Top Dead Center (BTDC) settings fall on the "A" side of "O".

5. Adjust timing by loosening distributor clamp and rotating distributor body as required until timing mark on balancer or pulley lines up with mark on tab specified in "Specifications" Section 8. Tighten clamp and recheck location of timing mark.
6. Stop engine and remove timing light.

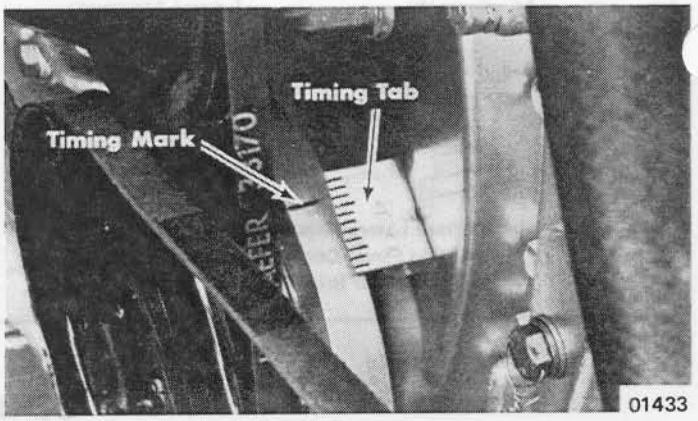


Figure 5. Timing Tab on "GM" V-8 Engines

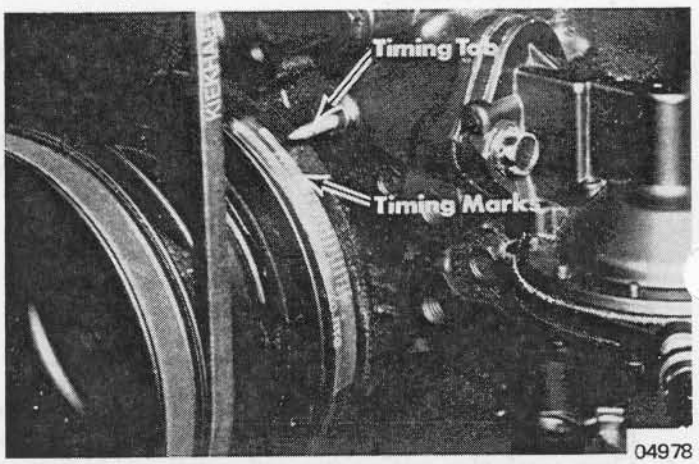


Figure 6. Timing Line on "Ford" V-8 Engines

THUNDERBOLT IGNITION SYSTEM

IMPORTANT: Thunderbolt Ignition System should be tested with Thunderbolt Ignition Analyzer (C-91-62563A1). Follow instruction manual included with analyzer. If analyzer is not available, proceed with following:

TEST PROCEDURES

SAFETY WARNING: When testing or servicing the ignition system, high voltage is present. Be extremely cautious. DO NOT TOUCH OR DISCONNECT any ignition system parts while engine is running, while key switch is on or while battery cables are connected. Keep engine compartment well ventilated. Gas vapor buildup is explosive.

Failure to comply with the following items may result in damage to the ignition system:

1. Do not reverse battery cable connections at the battery. System is negative (-) ground.
2. Do not "spark" battery terminals with battery cable connectors to check polarity.
3. Do not disconnect battery cables while engine is running.
4. Use only test equipment as specified. System cannot be checked with conventional ignition test equipment.
5. Follow service procedures in the order they are listed in the following information.

A process of elimination must be used when checking the ignition system (without Thunderbolt Ignition Analyzer C-91-62563A1), as the system's component parts cannot be checked with conventional ignition system test equipment. The following parts are required to check system:

1. Trigger assembly
2. Ignition coil assembly
3. Switch box assembly
4. Voltmeter (capable of reading 0-15 volts or more)
5. Short jumper lead and an ohmmeter

CHECKING for SPARK at SPARK PLUG LEAD

SAFETY WARNING: High voltage is present. DO NOT hold lead wire in hand when making this check.

1. Remove any one spark plug lead from spark plug.
2. Remove ground electrode from a standard type spark plug (not Polar Gap) and connect plug to spark plug lead and ground on engine. (Figure 7)

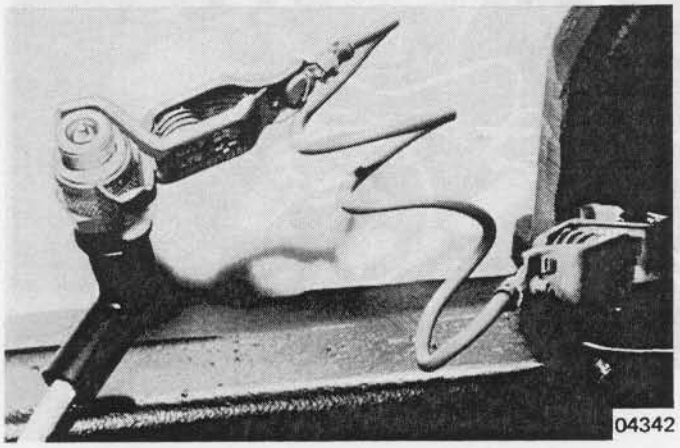


Figure 7. Checking for Spark at Spark Plug Lead

3. Crank engine over with starter and watch for spark across plug. If no spark is observed, proceed with the following check.

NOTE: If it is suspected that one or more cylinders are not firing properly or "missing", perform the preceding check on all spark plug leads.

CHECKING for SPARK at COIL

1. Remove secondary coil lead from distributor and position end of lead ½" (12.7mm) from ground. (Figure 8)

SAFETY WARNING: High voltage is present. DO NOT hold lead wire in hand when making this check.

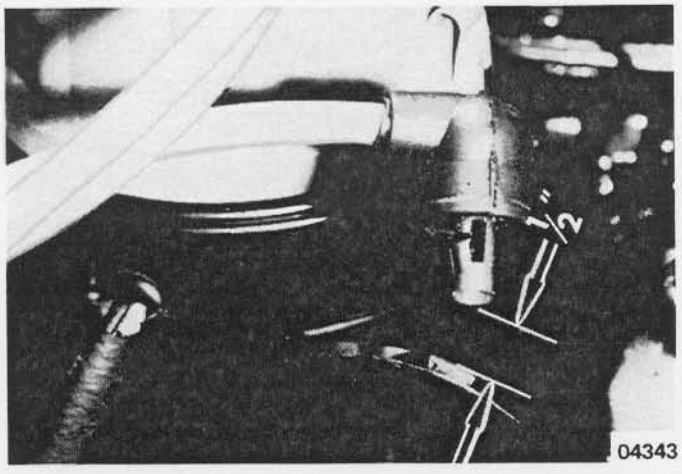


Figure 8. Checking for Spark at Coil

2. Crank engine over with starter and watch for spark across air gap between lead and ground.
   a. If spark is observed across air gap, cause for no spark in preceding "Checking for Spark at Spark Plug Lead" is in secondary section of distributor. Remove distributor cap and check rotor, inside of cap and lead wires. Replace damaged, worn or unserviceable parts.
   b. If no spark is observed across air gap, proceed with the following check.

CHECKING WIRING and CONNECTIONS

1. Connect positive voltmeter lead to terminal on switch box which has red wire connected to it. Connect negative voltmeter lead to ground on engine. (Figure 9)
2. With key switch in the "OFF" position, observe voltmeter.
   a. Meter should indicate battery voltage. If meter reading is below battery voltage or no voltage is indicated,

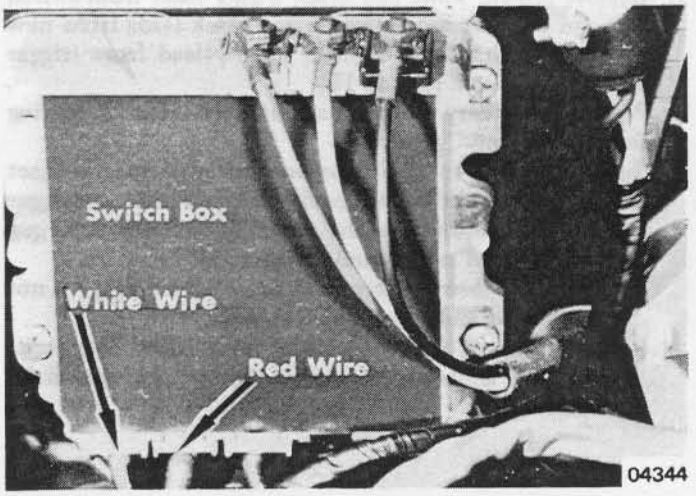


Figure 9. Voltmeter Connections

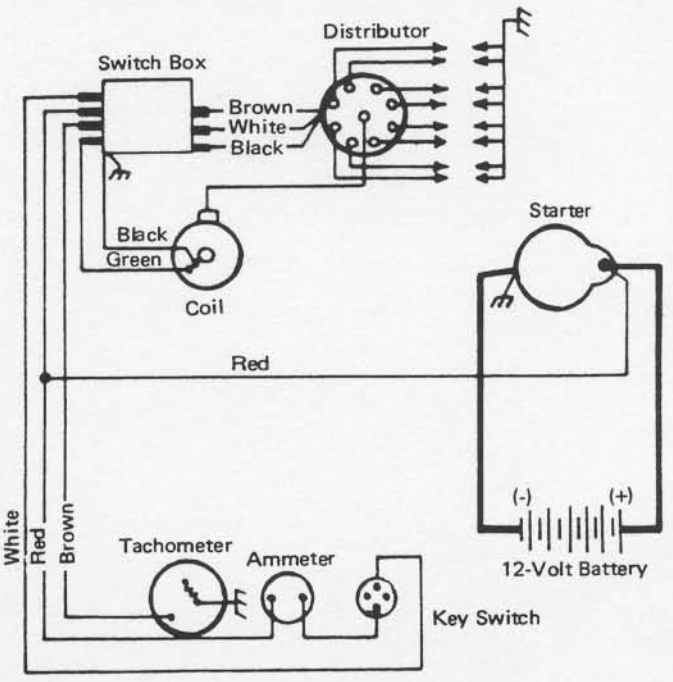


Figure 10. Schematic Diagram - Thunderbolt Ignition System

   check red wire with ohmmeter for an open circuit or high resistance. (Figure 10)
   b. If meter indicates battery voltage, proceed with the next step.
3. Remove positive voltmeter lead from red terminal on switch box and connect it to terminal which has white wire connected to it. (Figure 9)

4. With key switch in the "ON" position, observe voltmeter.
   a. Meter should indicate battery voltage. If meter reading is below battery voltage or no voltage is indicated, check white wire, key switch and wiring to key switch with ohmmeter for an open circuit or high resistance. (Figure 10)
   b. If meter indicates battery voltage, disconnect voltmeter, turn key to "OFF" and proceed with the following check.

CHECKING DISTRIBUTOR TRIGGER, SWITCH BOX and COIL

1. Remove brown, white and black trigger leads from switch box and connect brown, white and black leads from new trigger to switch box. Connect jumper lead from trigger housing to ground. (Figure 11)
2. Position secondary coil lead as outlined under "Checking for Spark at Coil", preceding.
3. Turn key switch to "ON" position and pass a metal object (feeler gauge, nail file, etc) back and forth between trigger inductance coils while, at the same time, observing air gap between coil lead and ground. (Figure 11)
   a. If spark is observed across air gap, original trigger is not functioning and should be replaced.
   b. If no spark is observed, and a "click"-like noise emits from the ignition coil, coil is shorted and should be replaced.
   c. If no spark is observed and coil click is not heard. remove test trigger and proceed as follows.
4. Remove wires from switch box and install new switch box.

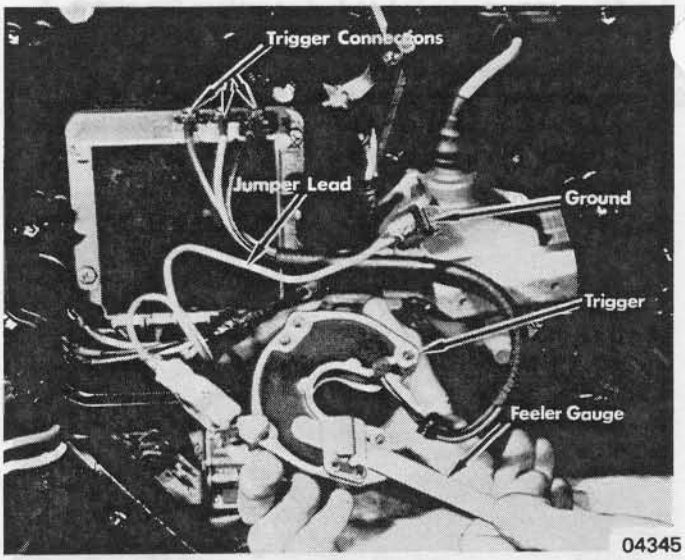


Figure 11. Checking Trigger

5. Connect all wires and repeat "Checking for Spark at Spark Plug Lead", preceding. If no spark is observed, install original switch box and replace ignition coil.

MERCRUISER 120-140-165 and 470 DISTRIBUTOR

Inspection (Distributor on Engine)

1. Remove distributor cap, clean cap and inspect for cracks, carbon tracks and burned-out or corroded terminals. Replace cap if necessary.
2. Make sure all distributor wire terminals are clean and tight.
3. Clean rotor and inspect for damage or deterioration. Replace rotor if necessary.
4. Inspect breaker assembly for damage, wear and dirty or badly pitted points. Replace if necessary. (See "Ignition Contact Points", following.)

NOTE: Use notch on outer edge of distributor cap (over primary wire) as a guide for proper replacement of cap. It is possible to install incorrectly.

Maintenance

Apply a light film of suitable high-melting-point, non-bleeding grease on distributor cam surface. Repeat every 100 hours of operation or once every year. Refer also to "Setting and Alignment of Points". (Use Index.)

Removal

NOTE: If necessary to remove secondary leads from distributor cap, mark position on cap tower for lead to No. 1 cylinder. This will aid in reinstallation of leads in cap.

1. Disconnect distributor primary lead from coil terminal.
2. Scratch a realignment mark on distributor in line with rotor notch (located on distributor shaft). (Figure 1)
3. Mark distributor housing in relation to engine block for ease in installation.
4. Remove distributor hold-down bolt and clamp and remove distributor from engine. Note position of assembly relative to engine for correct reinstallation.

CAUTION: Avoid rotating engine with distributor removed, as ignition timing will be upset.

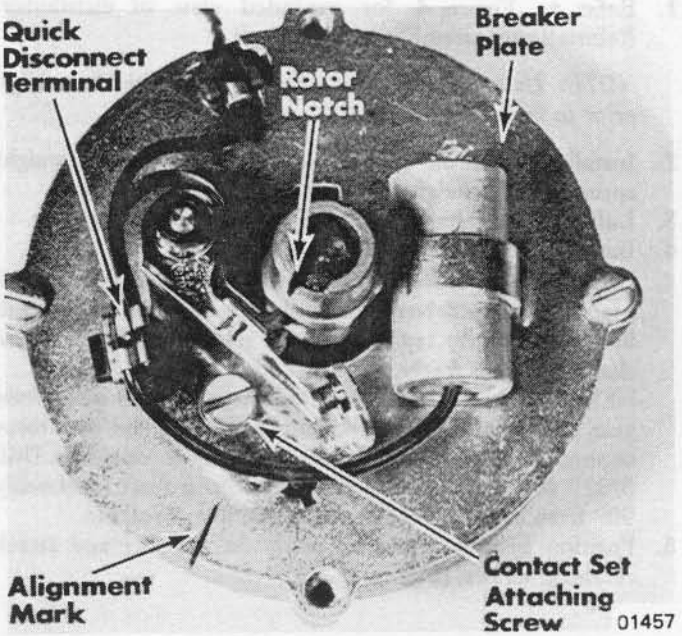


Figure 1. Breaker Plate and Attaching Parts

Disassembly

1. With distributor removed from engine, it is advisable to place it in a distributor testing machine or synchroscope.
2. When mounting distributor for tests, first secure gear in drive mechanism, then push distributor housing down toward gear to take up end play between gear and housing and, finally, secure housing in tester.
3. Test distributor for variation of spark, correct centrifugal advance and condition of contacts. This test evaluates distributor condition and possible parts replacement. Check area on breaker plate just beneath breaker points. A smudgy line indicates that oil or crankcase vapors are present between points.
   Refer to Figure 4 for exploded view of distributor.
4. Remove rotor.
5. Disconnect primary and condenser leads from contact point quick disconnect terminal. Remove contact point set attaching screw, condenser attaching screw and remove point set and condenser from breaker plate.
6. Remove breaker plate attaching screws and remove breaker plate from distributor housing. (Figure 1)
7. Remove roll pin retaining driven gear to main shaft and slide gear from shaft.
8. Slide cam and mainshaft from distributor housing.
9. Remove weight cover and stop plate screws. Remove cover, weight springs, weights and slide cam assembly from mainshaft.
10. Remove main shaft bushing felt washer from housing.

    NOTE: Main shaft bushings and oil seal in housing are not serviced separately. Housing, bushings and oil seal are serviced as complete assembly.

11. Remove gasket from shaft housing.

Cleaning and Inspection (Distributor Disassembled)

1. Wash all parts in cleaning solvent, except cap, rotor, condenser, breaker plate assembly. Degreasing compounds may damage insulation of these parts or saturate lubricating felt in case of breaker plate assembly.
2. Inspect breaker plate assembly for damage or wear and replace if necessary.
3. Inspect shaft for wear and check its fit in bushings in distributor body. If shaft or bushings are worn, replace shaft and distributor body.
4. Mount shaft in "V" blocks and check shaft alignment with a dial gauge. Run-out should not exceed .002" (.051mm).
5. Inspect weights for wear or burrs and free fit on their pins.
6. Inspect cam for wear or roughness, then check its fit on end of shaft. It should be free, but not loose.
7. Examine distributor points. Dirty points should be cleaned with a clean point file. Normal point condition is an overall grey color.
8. If a test instrument for checking resistance is available, check point resistance.
9. Evaluate point quality by visual inspection and a resistance or voltage drop check.
10. Replace points if badly worn, pitted or misaligned.
11. If, with points closed and ignition switch in "On" position, less than a 0.125 volt drop exists across points, points are satisfactory. Make this check with a sensitive voltmeter or a point resistance meter available for this purpose.
12. Test condenser for series resistance, microfarad capacity (.18 to .23), leakage or breakdown, following instructions given by manufacturer of test equipment used.
13. Inspect distributor cap and spark plug wires for damage.

Reassembly

1. Refer to Figure 4 for exploded view of distributor. Reinstall cam assembly to main shaft.

   NOTE: Lubricate top end of shaft with light engine oil prior to installing.

2. Install weights on their pivot pins and replace weight springs. Install weight cover and stop plate. (Figure 4)
3. Lubricate mainshaft and install it in distributor housing.
4. Install distributor driven gear as follows:
   USED GEAR - Install thrust washers (if applicable). Install used distributor driven gear to shaft with mark on gear hub in line with rotor segment. Insert retaining roll pin. Check that shaft turns freely.
   NEW GEAR - Install thrust washers if applicable. Press gear onto shaft with mark on gear hub in line with rotor segment until .030" (.76mm) end play is obtained. Drill 5/32" (4mm) hole thru gear shank and shaft (preferably 90° from existing hole in shaft) and install roll pin.
5. Position breaker plate assembly in housing and attach retaining screws. (Figure 1)
6. Attach condenser and contact point set in proper location with appropriate attaching screws.

   NOTE: Contact point set pilot must engage matching hole in breaker plate. Connect primary and condenser leads to contact set quick disconnect terminal.

7. Install rotor to cam assembly.

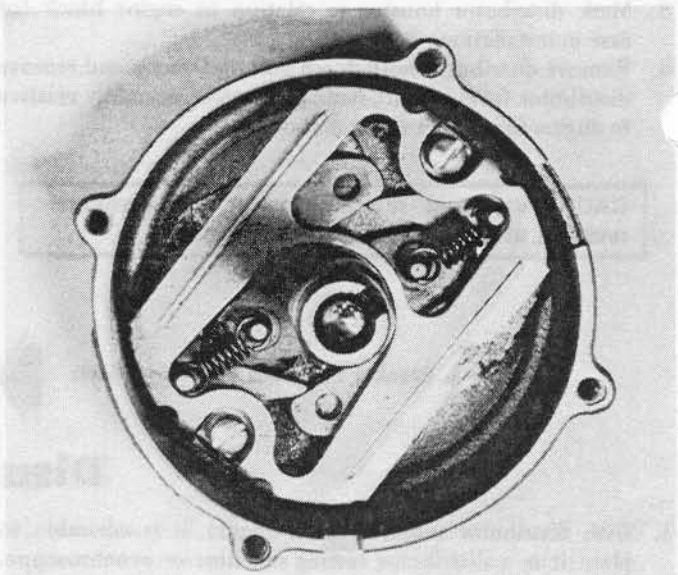


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Figure 2. Weights, Weight Cover Installed

Installation

ENGINE NOT TURNED with DISTRIBUTOR REMOVED

1. Turn rotor approximately 1/8-turn in a clockwise direction past mark previously scratched on distributor housing.
2. Work distributor down into position in engine block with distributor positioned as noted during removal.

   NOTE: It may be necessary to move rotor slightly to start gear into mesh with camshaft gear, but rotor should line up with the mark when distributor is down in place. Distributor shaft must enter oil pump shaft slot for complete installation.

3. Replace and tighten distributor hold-down bolt and clamp. Connect primary lead to coil. Also install spark plug and coil secondary wires, if removed. (Figure 3)

   NOTE: Wires must be installed, as indicated, to prevent cross-firing. Refer to Section 8, "Specifications", for firing order.

4. Time ignition as outlined under "Ignition Timing".

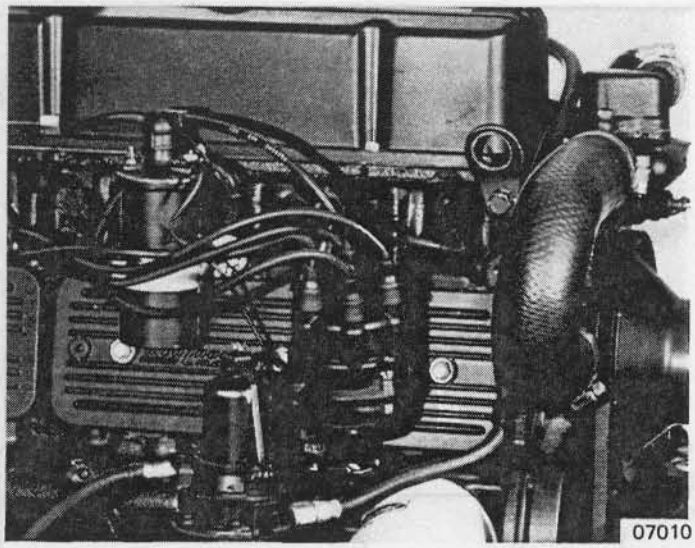
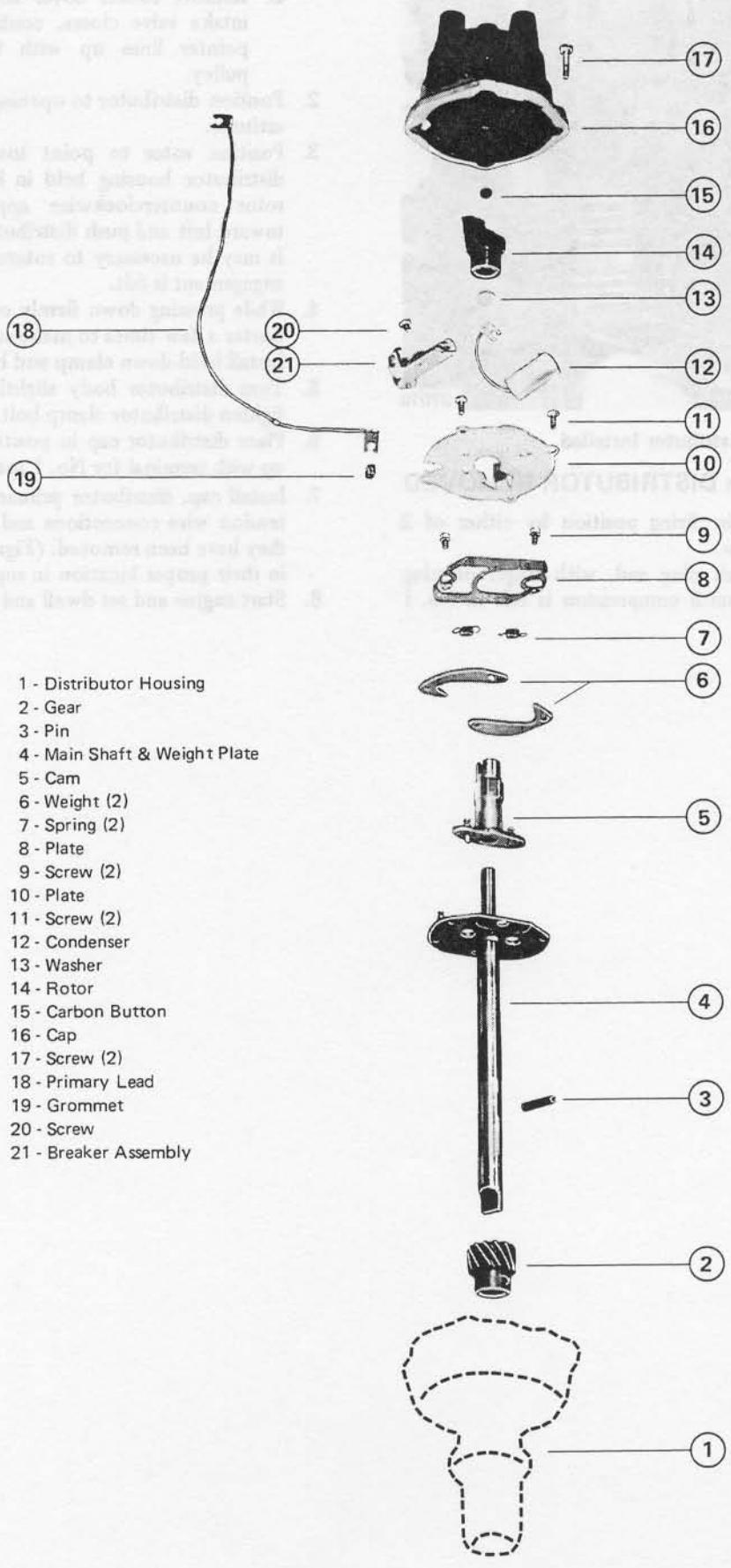


Figure 3. Distributor Installed

ENGINE TURNED with DISTRIBUTOR REMOVED

1. Locate No. 1 piston in firing position by either of 2 methods described below.
   a. Remove No. 1 spark plug and, with finger on plug hole, crank engine until compression is felt in No. 1 cylinder. Continue cranking until pointer lines up with timing mark on crankshaft pulley or . . .
   b. Remove rocker cover and crank engine until No. 1 intake valve closes, continuing to crank slowly until pointer lines up with timing mark on crankshaft pulley.
2. Position distributor to opening in block in normal installed attitude.
3. Position rotor to point toward front of engine (with distributor housing held in installed attitude), then turn rotor counterclockwise approximately 1/8-turn more toward left and push distributor down to engage camshaft. It may be necessary to rotate rotor slightly until camshaft engagement is felt.
4. While pressing down firmly on distributor housing, engage starter a few times to make sure oil pump shaft is engaged. Install hold-down clamp and bolt and snug up bolt.
5. Turn distributor body slightly until points just open and tighten distributor clamp bolt.
6. Place distributor cap in position and check that rotor lines up with terminal for No. 1 spark plug.
7. Install cap, distributor primary lead to coil. Check all high tension wire connections and connect spark plug wires, if they have been removed. (Figure 3) Wires must be installed in their proper location in supports to prevent cross-firing.
8. Start engine and set dwell and timing.



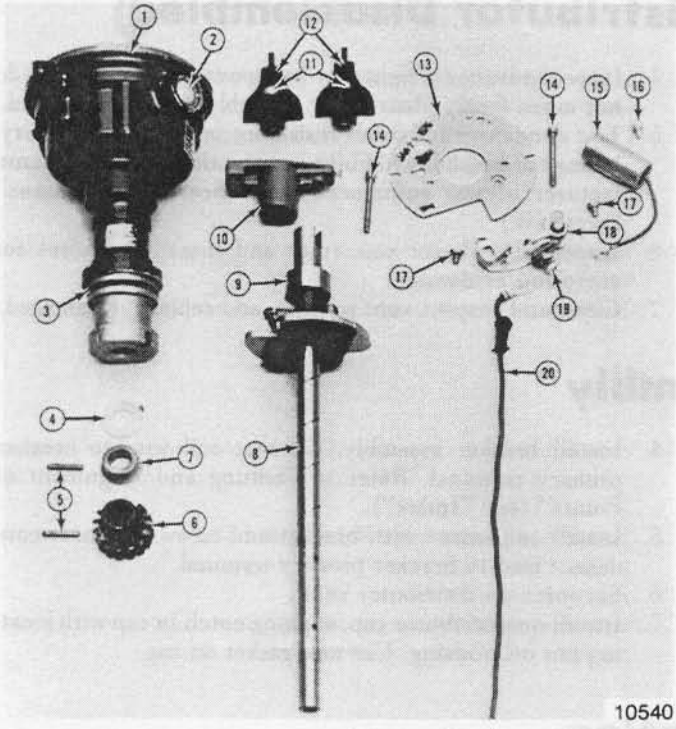
1 - Distributor Housing
2 - Gear
3 - Pin
4 - Main Shaft & Weight Plate
5 - Cam
6 - Weight (2)
7 - Spring (2)
8 - Plate
9 - Screw (2)
10 - Plate
11 - Screw (2)
12 - Condenser
13 - Washer
14 - Rotor
15 - Carbon Button
16 - Cap
17 - Screw (2)
18 - Primary Lead
19 - Grommet
20 - Screw
21 - Breaker Assembly

Figure 4. Distributor, 120-140-165-470 Engines, Exploded View (Typical)

MERCURY MARINE DISTRIBUTOR

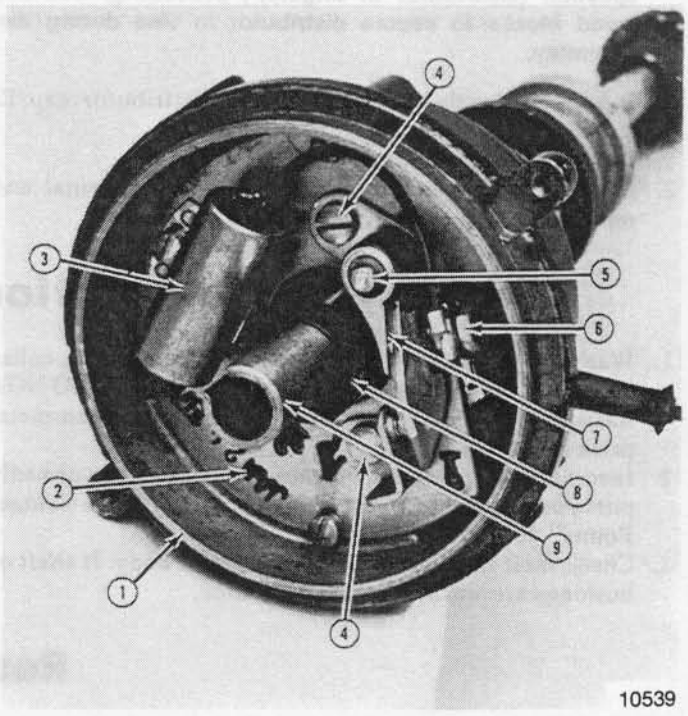
Inspection (Distributor on Engine) (Figure 1)

1. Remove distributor cap. Clean and inspect for cracks, carbon tracks and burned-out or corroded terminals. Replace cap if necessary.
2. Make sure that all distributor wire terminals are clean and tight.
3. Clean rotor and inspect for damage or deterioration. Replace rotor if necessary.
4. Inspect breaker assembly (Figure 2) for damage, wear, dirty or badly pitted points. Replace if necessary. See "Ignition Contact Points" (use "Index").
5. Test condenser for series resistance, microfarad capacity and leakage or breakdown, following instructions given by manufacturer of test equipment used. (Refer to Section 8 for specifications.)
6. Check distributor bushings for wear. Attach dial indicator to distributor housing. Position registering point of dial indicator to rest on distributor shaft. Shaft must not have more than .002" (.051mm) side play within bushings when shaft is pushed back-and-forth by hand.
7. Check for sticking centrifugal weights. Grip distributor shaft (or rotor) and twist in direction of rotation, then release. Shaft should snap back to its original position. If it hangs up, returns sluggishly or slowly, distributor must be replaced.



1 - Housing
2 - Vent Screen
3 - O-Ring
4 - Tab Washer
5 - Roll Pins (2)
6 - Drive Gear
7 - Collar
8 - Shaft Assembly
9 - Cam
10 - Rotor
11 - Cap Retainer Screws (2)
12 - Cap Retainers (2)
13 - Breaker Plate
14 - Breaker Plate Retaining Screws w/Washers (2)
15 - Condenser
16 - Condenser Screw
17 - Breaker Points Retaining Screws (2)
18 - Breaker Point Set
19 - Primary Terminal Nut
20 - Coil Lead

Figure 1. Exploded View - Mercury Marine Distributor



1 - Housing
2 - Breaker Plate
3 - Condenser
4 - Breaker Points Retaining Screws (2)
5 - Breaker Points Pilot
6 - Primary Terminal Nut
7 - Breaker Points
8 - Cam
9 - Shaft

Figure 2. Breaker Plate Components

Maintenance

Apply a light film of suitable high-melting-point, non-bleeding grease on distributor cam surface. Repeat every 50 hours of operation or once every year. Refer also to "Setting and Alignment of Points" (use "Index").

Removal

1. Remove distributor cap (2 screws) and gasket. DO NOT remove plug wires from cap.
2. Disconnect coil primary lead from coil.
3. Crank or turn engine slowly. Align timing marks when rotor is pointing to No. 1 terminal of distributor cap. If same distributor is to be reinstalled in engine, mark position of distributor housing in relation to engine so that distributor may be installed in same position.
4. Remove distributor retaining clamp (one screw).
5. Remove distributor.

NOTE: To simplify distributor installation. DO NOT turn crankshaft with distributor removed from engine.

Disassembly

IMPORTANT: DO NOT disassemble distributor if not necessary. When checking for worn parts, refer to "Inspection (Distributor in Engine)", preceding. Use soft wood blocks to secure distributor in vise during disassembly.

1. If not previously removed, remove distributor cap (2 screws).
2. Lift rotor off distributor shaft.
3. Disconnect condenser lead from primary terminal and remove retaining screw, bracket and condenser.
4. Disconnect coil wire from primary terminal and remove retaining screws and breaker assembly.
5. Drive pin from drive gear and remove gear from shaft.
6. Remove 2 screws from breaker plate and remove plate.
7. Drive pin from collar and remove collar and washer from shaft. Remove shaft assembly from housing.

NOTE: This completes disassembly of distributor. Further disassembly of housing or shaft assembly is not recommended, as individual parts for further servicing are not available.

Cleaning and Inspection (Distributor Disassembled)

1. Wash breaker plate, housing assembly, drive gear, collar and all washers and fasteners in cleaning solvent. DO NOT wash shaft assembly, condenser, points or any non-metal parts in solvent.
2. Inspect breaker assembly for damage, wear, dirty or badly pitted points. Replace if necessary. (See "Ignition Contact Points" [use "Index"].)
3. Check shaft fit in bushings in distributor body. If shaft or bushings are worn, replace distributor.
4. Inspect advance weights for free movement. If weights do not move freely, distributor assembly must be replaced.
5. Test condenser for series resistance, microfarad capacity, leakage or breakdown. Follow instructions given by manufacturer of test equipment used. (See "Specifications" Section 8.)
6. Inspect distributor cap, rotor and spark plug wires for corrosion or damage.
7. Clean and inspect vent screens and replace if damaged.

Reassembly

NOTE: Refer to Figure 1 for clarification of parts.

1. Replace shaft assembly into housing and replace breaker plate (2 screws).
2. Replace washer and collar on shaft and secure with new roll pin.
3. Install drive gear on distributor shaft (shoulder end first) and install a new pin through gear shoulder and shaft.
4. Install breaker assembly. Connect coil wire to breaker primary terminal. Refer to "Setting and Alignment of Points" (see "Index").
5. Install condenser with bracket and screw. Connect condenser lead to breaker primary terminal.
6. Set rotor on distributor shaft.
7. Install on distributor cap, aligning notch in cap with locating pin on housing. Use new gasket on cap.

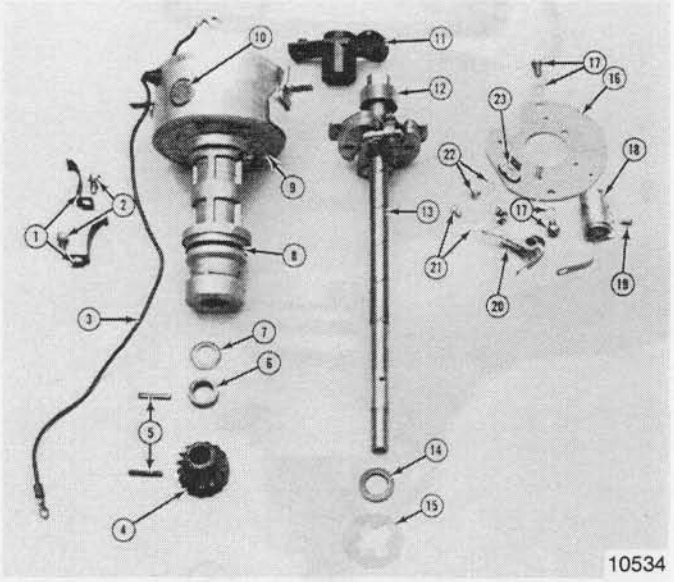
Installation

1. With rotor installed, place distributor into engine with rotor pointed in same direction as original distributor. (No. 1 tower terminal) Center distributor so that initial timing may be adjusted. (Distributor should rotate approximately 45°.) If original distributor is being installed, align location marks (made during removal) on distributor housing and engine.
2. Install retaining clamp and screw.
3. Connect primary wire to coil primary terminal.
4. Place gasket on distributor cap. Align notch in cap with locating pin on housing and install distributor cap. If new distributor cap is being used, transfer high tension wires from old cap to new cap. Make sure that No. 1 cylinder wire is installed into high tension tower where rotor is pointing. Install remaining wires into cap one-at-a-time in same sequence that wires are removed from original cap.
5. Start engine. Observe oil pressure. No pressure indicates improper seating of distributor shaft with oil pump drive.
6. Use a timing light and set timing as described under "Ignition Timing" (see "Index").

PRESTOLITE DISTRIBUTOR

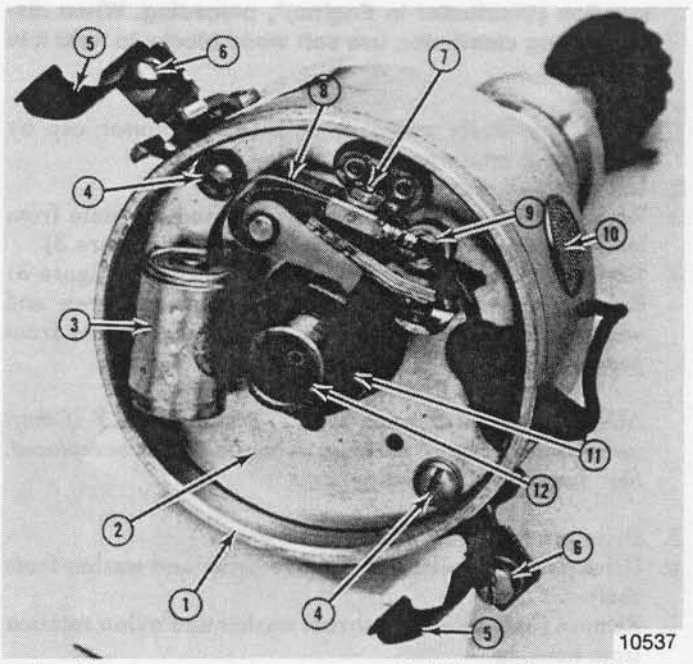
Inspection (Distributor on Engine) (Figure 1)

1. Remove distributor cap by loosening 2 retaining screws (DO NOT try to spring clips, as they will lose tension). Clean and inspect for cracks, carbon tracks and burned-out or corroded terminals. Replace cap if necessary.
2. Make sure that all distributor wire terminals are clean and tight.
3. Clean rotor and inspect for damage or deterioration. Replace rotor if necessary.
4. Inspect breaker assembly (Figure 2) for damage, wear, dirty or badly pitted points. Replace if necessary. See "Ignition Contact Points" (use "Index").



1 - Cap Retaining Clips (2)
2 - Retaining Clip Screws w/ Washers (2)
3 - Coil Lead
4 - Drive Gear
5 - Roll Pins (2)
6 - Collar
7 - Washer
8 - O-Ring
9 - Housing
10 - Vent Screen
11 - Rotor
12 - Cam
13 - Shaft Assembly
14 - Thrust Washer
15 - Nylon Retainer
16 - Breaker Plate
17 - Breaker Plate Retaining Screws w/Lockwashers (2)
18 - Condenser
19 - Condenser Screw
20 - Breaker Points
21 - Breaker Point Retaining Screw and Washer
22 - Primary Terminal Screw and Washer
23 - Primary Terminal

Figure 1. Exploded View - Prestolite Distributor



1 - Housing
2 - Breaker Plate
3 - Condenser
4 - Breaker Plate Retaining Screws w/Lockwashers (2)
5 - Cap Retaining Clips (2)
6 - Retaining Clip Screws w/ Washers (2)
7 - Primary Terminal Screw
8 - Condenser Lead Strap
9 - Breaker Points Retaining Screw
10 - Vent Screen
11 - Cam
12 - Shaft

Figure 2. Breaker Plate Components

5. Test condenser for series resistance, microfarad capacity and leakage or breakdown, following instructions given by manufacturer of test equipment used. (Refer to Section 8 for specifications.)
6. Check distributor bushings for wear. Attach dial indicator to distributor housing. Position registering point of dial indicator to rest on distributor shaft. Shaft must not have more than .002" side play within bushings when shaft is pushed back-and-forth by hand.
7. Check for sticking centrifugal weights. Grip distributor shaft (or rotor) and twist in direction of rotation, then release. Shaft should snap back to its original position. If it hangs up, returns sluggishly or slowly, shaft assembly must be replaced.

Maintenance

Apply a light film of suitable high-melting-point, non-bleeding grease on distributor cam surface. Repeat every 50 hours of operation or once every year. Refer also to "Setting and Alignment of Points" (use "Index").

Removal

1. Remove distributor cap by loosening 2 retaining screws and remove gasket. DO NOT remove plug wires from cap.
2. Disconnect coil primary lead from coil.
3. Crank or turn engine slowly. Align timing marks when rotor is pointing to No. 1 terminal of distributor cap. If same distributor is to be reinstalled in engine, mark position of distributor housing in relation to engine so that distributor may be installed in same position.
4. Remove distributor retaining clamp (one screw).
5. Remove distributor.

NOTE: To simplify distributor installation. DO NOT turn crankshaft with distributor removed from engine.

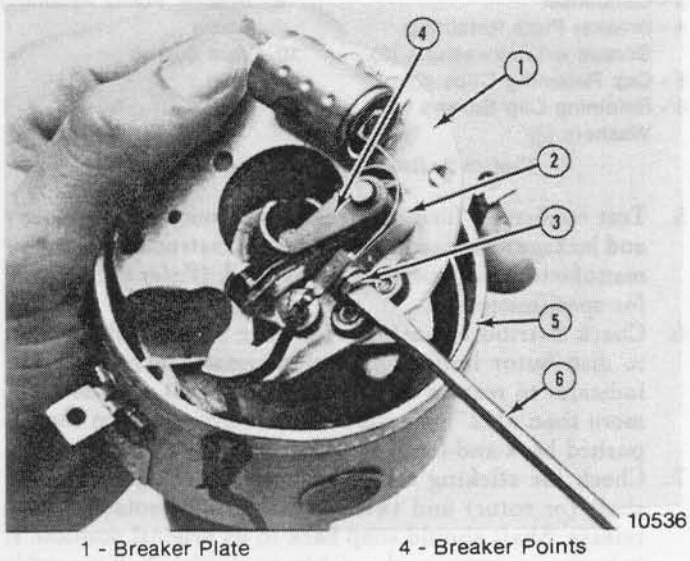
Disassembly

IMPORTANT: DO NOT disassemble distributor if not necessary. When checking for worn parts, refer to "Inspection (Distributor in Engine)", preceding. When disassembling distributor, use soft wood blocks to hold it in a vise.

1. If not previously removed, remove distributor cap by loosening 2 retaining screws.
2. Lift rotor off distributor shaft.
3. Remove 2 screws from breaker plate and lift plate from housing without pulling coil primary lead. (Figure 3)
4. Remove primary terminal screw and washer. (Figure 3) Remove condenser screw and breaker points screw and washer and remove condenser and breaker points from plate.

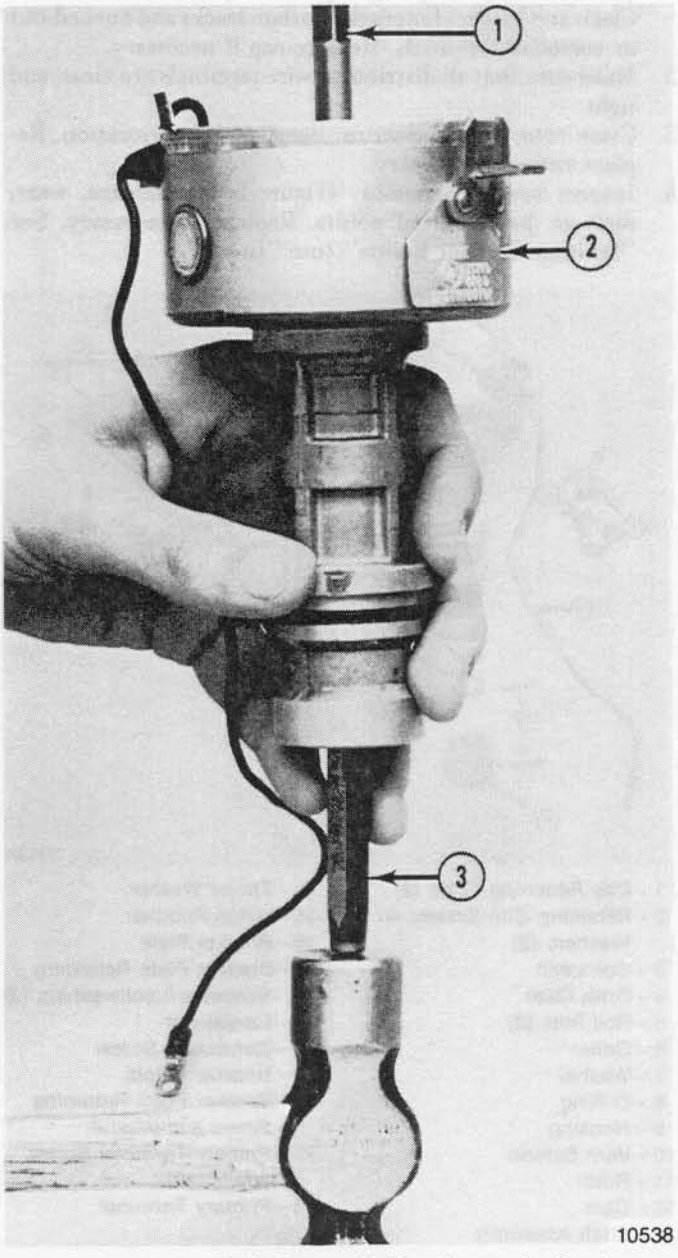
NOTE: Proceed with Steps 5, 6, 7, 8 and 9 ONLY if shaft assembly and/or shaft bushings in housing are to be replaced. See "Inspection", preceding.

5. Drive pin from gear and remove gear.
6. Drive pin from collar and remove collar and washer from shaft.
7. Remove shaft assembly, thrust washer and nylon retainer from housing.
8. Thread a ½x13 or ½x20 tap into the upper shaft bushing. (Figure 4) Using a suitable punch, drive tap and bearing out of housing.
9. Repeat procedure in Step 8 for the lower bushing.



1 - Breaker Plate
2 - Condenser Lead Strap
3 - Primary Terminal Screw
4 - Breaker Points
5 - Housing
6 - Screwdriver

Figure 3. Primary Terminal Screw



1 - 1/2x13 or 1/2x20 Tap
2 - Housing
3 - Punch

Figure 4. Removing Bushing

Cleaning and Inspection (Distributor Disassembled)

1. Wash breaker plate, gear, collar and all washers and fasteners in cleaning solvent. If bushings are removed ("Disassembly", Steps 6-9, preceding), wash housing in solvent after removing coil lead wire. DO NOT wash points, condenser or any non-metal parts in solvent.
2. Inspect breaker assembly for damage, wear, dirty or badly pitted points. Replace if necessary. (See "Ignition Contact Points", preceding.)
3. Inspect advance weights for wear or burrs and free fit on their pins. If worn, replace distributor shaft assembly.
4. Inspect cam for wear or roughness. Check cam fit on end of shaft. It should be free, but not loose. If worn, replace distributor.
5. Test condenser for series resistance, microfarad capacity, leakage or breakdown. Follow instructions given by manufacturer of test equipment used. (See "Specifications" Section 8.)
6. Inspect distributor cap, rotor and spark plug wires for corrosion or damage.

Reassembly

1. If bushings were removed from housing ("Disassembly", steps 6-9), drive in NEW bushings, using ½" socket or other suitable cylindrical object having the same outside diameter as the bushings. Upper bushing will seat, lower bushing should be driven slightly beyond the point of being flush. Replace nylon retainer (after installing lubricant in grooves) and thrust washer.
2. Replace shaft assembly into housing.
3. Place washer and collar on shaft and drive in new roll pin.
4. Place drive gear on shaft and install new roll pin.
5. Install breaker points and condenser on plate, securing with screws. Attach point spring, condenser strap and coil lead to primary terminal (Figure 3) and install primary terminal screw.
6. Place breaker plate in housing and install 2 screws with washers.
7. Set point gap and point spring tension according to "Specifications" Section 8 (see also "Setting and Alignment of Points", preceding).
8. Set rotor on shaft, aligning flat side of shaft with flat surface in rotor, and seat rotor on shaft.
9. Install new gasket on cap, and place cap on housing, aligning tab on cap with locater on housing. Replace retainer clips and tighten screws (DO NOT spring clips into place, or they will loose tension).

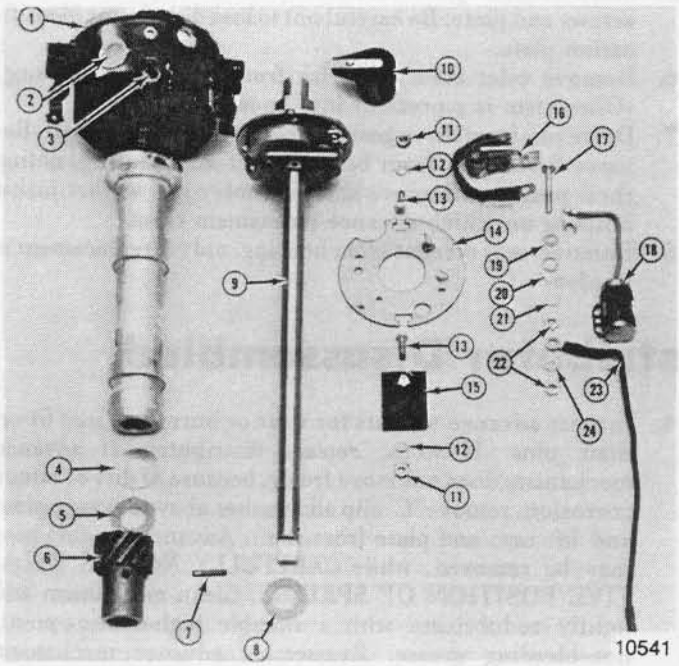
Installation

1. With rotor installed, place distributor into engine with rotor pointed in same direction as original distributor. (No. 1 tower terminal) Center distributor so that initial timing may be adjusted. (Distributor should rotate approximately 45°.) If original distributor is being installed, align location marks (made during removal) on distributor housing and engine.
2. Install retaining clamp and screw.
3. Connect primary wire between coil primary terminal and distributor primary terminal.
4. Place gasket on distributor cap. Align tab on cap with locating pins on housing and install distributor cap. If new distributor cap is being used, transfer high tension wires from old cap to new cap. Make sure that No. 1 cylinder wire is installed into high tension tower where rotor is pointing. Install remaining wires into cap one-at-a-time in same sequence that wires are removed from original cap.
5. Start engine. Observe oil pressure. No pressure indicates improper seating of distributor shaft with oil pump drive.
6. Use a timing light and set timing as described under "Ignition Timing", preceding.

MALLORY DISTRIBUTOR

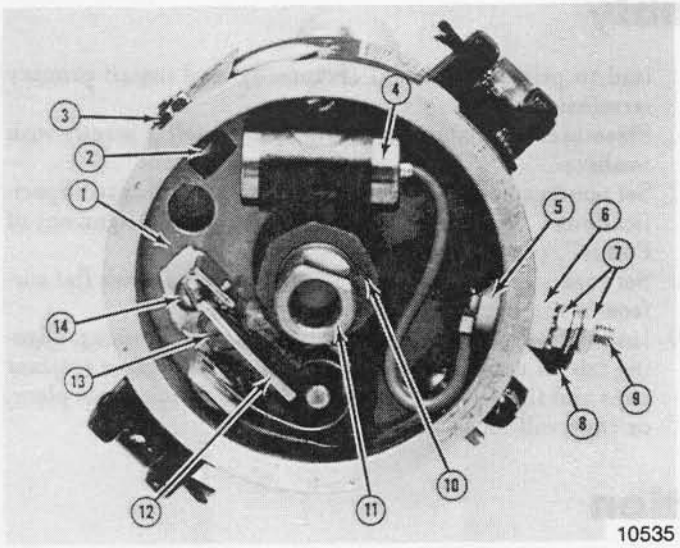
Inspection (Distributor on Engine) (Figure 1)

1. Remove distributor cap. Clean and inspect for cracks, carbon tracks and burned-out or corroded terminals. Replace cap if necessary.
2. Make sure that all distributor wire terminals are clean and tight.
3. Clean rotor and inspect for damage or deterioration. Replace rotor if necessary.
4. Inspect breaker assembly (Figure 2) for damage, wear, dirty or badly pitted points. Replace if necessary. See "Ignition Contact Points", preceding.
5. Test condenser for series resistance, microfarad capacity and leakage or breakdown, following instructions given by manufacturer of test equipment used. (Refer to Section 8 for specifications.)
6. Check distributor bushings for wear. Attach dial indicator to distributor housing. Position registering point of dial indicator to rest on distributor shaft. Shaft must not have more than .002" side play within bushings when shaft is pushed back-and-forth by hand.



1 - Housing
2 - Vent Screen
3 - Oiler Stem
4 - Washer (Steel)
5 - Washer (Brass)
6 - Drive Gear
7 - Roll Pin
8 - Thrust Washer
9 - Shaft Assembly
10 - Rotor
11 - Breaker Plate Nut (2)
12 - Breaker Plate Lockwasher (2)
13 - Breaker Plate Screw (2)
14 - Breaker Plate
15 - Identification Tag
16 - Breaker Points
17 - Primary Terminal Screw
18 - Condenser
19 - Primary Terminal Inner (Smaller) Bushing
20 - Primary Terminal Outer (Larger) Bushing
21 - Star Washer
22 - Primary Terminal Nut (2)
23 - Coil Lead
24 - Lockwasher

Figure 1. Exploded View - Mallory Distributor



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1 - Breaker Plate
2 - Breaker Plate Retaining Screw (2)
3 - Nut (2)
4 - Condenser
5 - Primary Terminal Inner Bushing
6 - Primary Terminal Outer Bushing
7 - Nuts (2)
8 - Coil Lead
9 - Primary Terminal Screw
10 - Cam
11 - Shaft
12 - Breaker Points
13 - Breaker Point Adjusting Screw
14 - Breaker Point Retaining Screw

Figure 2. Breaker Plate Components

7. Check for sticking centrifugal weights. Grip distributor shaft (or rotor) and twist in direction of rotation, then release. Shaft should snap back to its original position. If it hangs up, returns sluggishly or slowly, distributor must be serviced or replaced.

Maintenance

1. Apply a light film of suitable high-melting-point, non-bleeding grease on distributor cam surface. Repeat every 50 hours of operation or once every year.
2. Add 5 to 7 drops of engine oil in oiler tube for bushing lubrication every 50 hours of operation or once every year.
3. Adjust breaker points, as explained under "Setting and Alignment of Points", preceding.

Removal

1. Remove distributor cap (2 screws) and gasket. Do not remove plug wires from cap.
2. Disconnect coil primary lead from distributor.
3. Crank or turn engine slowly. Align timing marks when rotor is pointing to No. 1 terminal of distributor cap. If same distributor is to be reinstalled in engine, mark position of distributor housing in relation to engine so that distributor may be installed in same position.
4. Remove distributor retaining clamp (one screw).
5. Remove distributor.

NOTE: To simplify distributor installation, DO NOT turn crankshaft with distributor removed from engine.

Disassembly

IMPORTANT: DO NOT disassemble distributor if not necessary. When checking for worn parts, refer to "Inspection (Distributor in Engine)", preceding. Use soft wood blocks to secure distributor in vise during disassembly.

1. If not previously removed, remove distributor cap (2 screws) and distributor cap gasket.
2. Lift rotor off distributor shaft.
3. Disconnect condenser lead from primary terminal and remove retaining screw, bracket and condenser.
4. Disconnect breaker assembly lead from primary terminal and remove retaining screw and breaker assembly.
5. Mark breaker plate location and remove plate retaining screws and plate. Be careful not to lose distributor identification plate.
6. Remove oiler stem and wick from distributor housing. (Oiler stem is a press fit into housing.)
7. Drive pin from drive gear and remove gear from shaft. Remove 2 washers from between gear and housing, noting their position. Remove shaft assembly and washer inside housing on which advance mechanism rides.
8. Remove vent screens from housing, only if replacement is needed.

Cleaning and Inspection (Distributor Disassembled)

1. Wash breaker plate, housing assembly, drive gear and all washers and fasteners in cleaning solvent. DO NOT wash shaft assembly, condenser, points or any non-metal parts in solvent.
2. Inspect breaker assembly for damage, wear, dirty or badly pitted points. Replace if necessary. (See "Ignition Contact Points", preceding.)
3. Check shaft fit in bushings in distributor body. If shaft or bushings are worn, replace distributor.
4. Inspect advance weights for wear or burrs and free fit on their pins. If worn, replace distributor. If advance mechanism does not move freely, because of dirt or minor corrosion, remove 'C' clip and washer above advance plate and lift cam and plate from shaft. Advance weights now may be removed, while CAREFULLY NOTING RELATIVE POSITION OF SPRINGS. Clean mechanism and lightly re-lubricate with a suitable high-melting-point, non-bleeding grease. Reassemble advance mechanism

while spring and weight positions are familiar.

5. Inspect cam for wear or roughness. Check cam fit on end of shaft. It should be free, but not loose. If worn, replace distributor.
6. Test condenser for series resistance, microfarad capacity, leakage or breakdown. Follow instructions given by manufacturer of test equipment used. (See "Specifications" Section 8.)
7. Inspect distributor cap, rotor and spark plug wires for corrosion or damage.
8. Clean vent screens or remove if damaged.

Reassembly

1. Install new vent screens in distributor housing vent holes (if old ones are removed). Crimp inside flange to secure screen in housing.
2. Place washer on distributor shaft assembly and install shaft through housing.
3. Install drive gear and 2 washers on shaft (steel washer toward housing, brass washer toward gear). Install a new pin through shoulder of gear and shaft and peen ends of pin to prevent its falling out.
4. Insert oil wick into distributor housing oiler hole and press oiler stem into hole.
5. Install breaker plate screws, identification plate, washers and nuts. Do not tighten nuts. Install breaker plate. Align location marks made during disassembly and tighten nuts.
6. Install breaker assembly. Connect breaker assembly lead to distributor primary terminal. Refer to "Setting and Alignment of Points", preceding.
7. Install condenser with bracket and screw. Connect condenser lead to distributor primary terminal.
8. Set rotor on distributor shaft, aligning slot on inside diameter of rotor with flat side of shaft.
9. Install gasket on distributor cap. Align notch in cap with locating pin on housing and install cap.

Installation

1. With rotor installed, place distributor into engine with rotor pointed in same direction as original distributor. (No. 1 tower terminal) Center distributor so that initial timing may be adjusted. (Distributor should rotate approximately 45°.) If original distributor is being installed, align location marks (made during removal) on distributor housing and engine.
2. Install retaining clamp and screw.
3. Connect primary wire between coil primary terminal and distributor primary terminal.
4. Place gasket on distributor cap. Align notch in cap with locating pin on housing and install distributor cap. If new distributor cap is being used, transfer high tension wires from old cap to new cap. Make sure that No. 1 cylinder wire is installed into high tension tower where rotor is pointing. Install remaining wires into cap one-at-a-time in same sequence that wires are removed from original cap.
5. Start engine. Observe oil pressure. No pressure indicates improper seating of distributor shaft with oil pump drive.
6. Use a timing light and set timing as described under "Ignition Timing", preceding.

THUNDERBOLT IGNITION DISTRIBUTOR

Removal

1. Disconnect positive (+) battery cable from battery.
2. Remove cover from switch box.
3. Disconnect brown, white and black trigger leads from terminals located on switch box.
4. Place a mark on distributor adaptor housing adjacent to No. 1 cylinder distributor cap tower. (Figure 1)

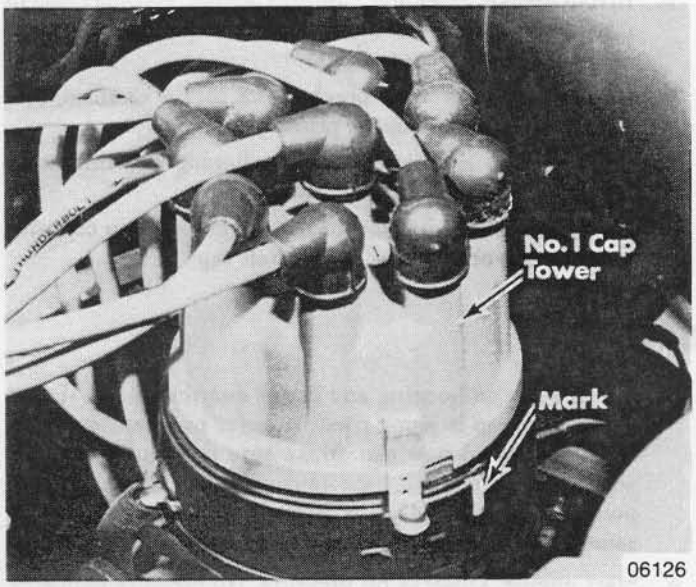


Figure 1. Marking Adaptor Housing

5. Loosen distributor cap retaining screws and remove distributor cap.
6. Rotate crankshaft (in normal direction of rotation) until distributor rotor lines up with mark on adaptor housing (Figure 2) and timing mark, which is located on torsional damper, is in line with top dead center mark located on timing tab. (Figure 3)

   NOTE: No. 1 cylinder now is positioned at top dead center of its compression stroke.

7. Remove screw which fastens distributor ground wire to intake manifold.

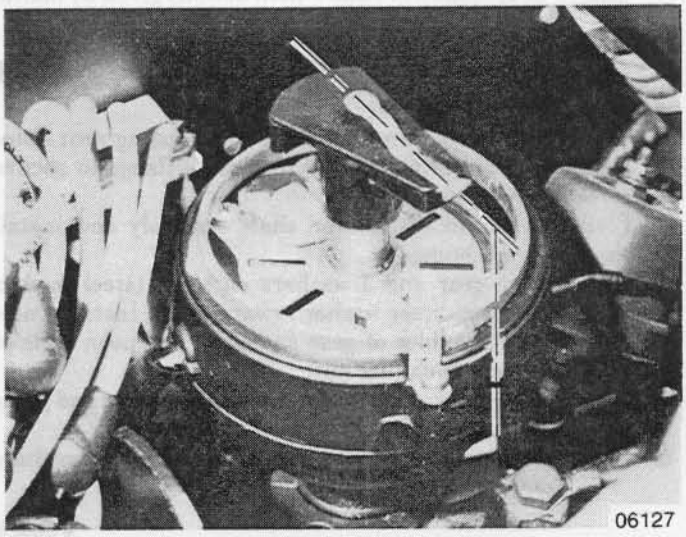


Figure 2. Rotor Aligned with Mark

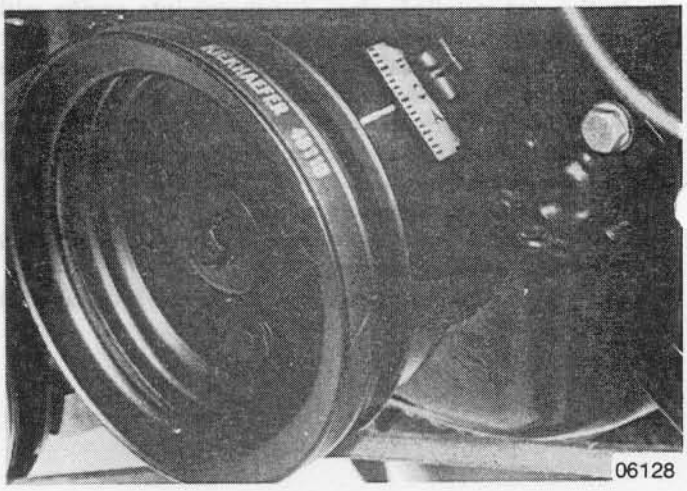


Figure 3. Timing Marks Aligned - Top Dead Center

8. Remove distributor hold-down screw and clamp and lift distributor up out of engine. Remove distributor to intake manifold gasket.

Disassembly

1. Place a mark on adaptor housing and distributor pilot to aid in reassembly. (Figure 4)
2. Remove rotor from distributor shaft by pulling rotor straight up.

   NOTE: If rotor is not damaged or worn, and replacement is not required, do not remove it from shaft. Loctite (C-92-32609) is used to retain rotor to shaft.
   Be careful when removing rotor, so that distributor shaft does not bend nor that slotted disc becomes damaged.

3. Remove 4 screws and lockwashers, which fasten adaptor housing to pilot, and remove adaptor housing.

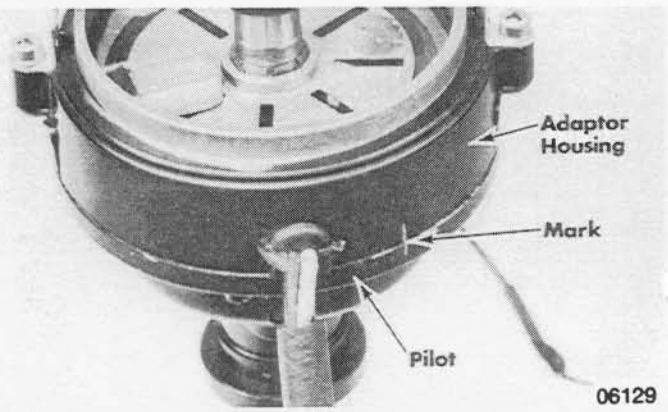


Figure 4. Adaptor Housing and Pilot

4. Remove 4 screws and lockwashers, which fasten trigger assembly to pilot, and remove trigger. (Figure 5)
5. Support gear in a suitable fixture and drive pin out of gear and shaft. Remove gear from shaft.

This completes disassembly of distributor. Further disassembly of pilot and shaft assembly is not recommended, as special fixtures are required to reassemble. Also, individual parts for servicing pilot and shaft assembly are not available.

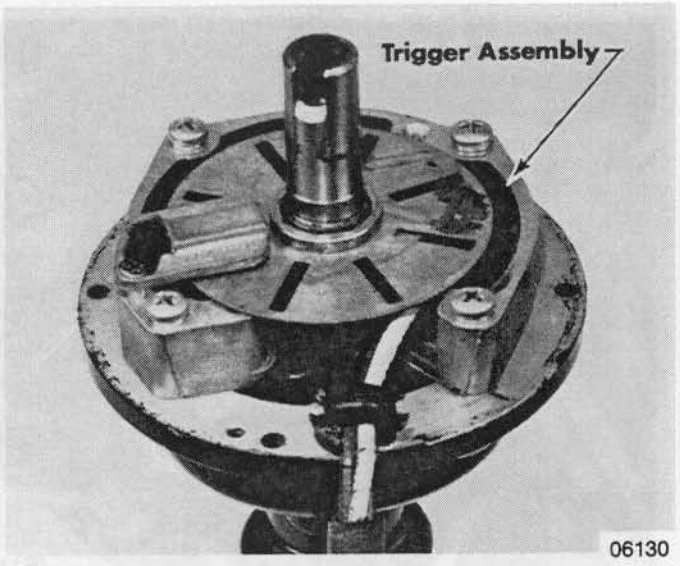


Figure 5. Trigger Assembly

Reassembly

1. Place gear on shaft, indexing alignment notch and mark on gear as shown in Figure 6. Support gear in a suitable fixture and install new roll pin.
2. Place trigger assembly in position on pilot and fasten trigger to pilot with 4 screws and lockwashers. (Figure 5)
3. Place adaptor housing in position on pilot and fasten adaptor housing to pilot with 2 screws and lockwashers. (Figure 4)
4. Apply 4 drops of Loctite "A" (C-92-32609) to inside of rotor and place rotor on shaft.

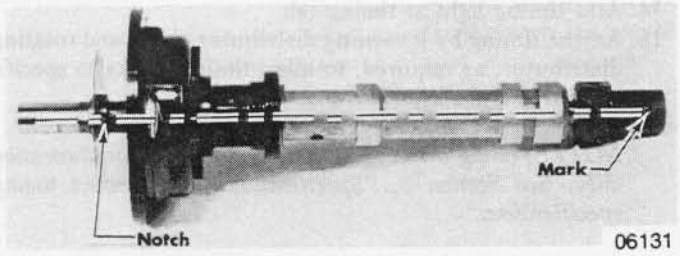


Figure 6. Distributor Gear and Shaft Indexing

Installation

1. Prior to installing distributor, No. 1 piston must be positioned at top dead center of its compression stroke.
   If piston position has been disturbed since performing Step 6, listed under "Removal", proceed as follows:
   a. Remove rocker arm cover from left cylinder head.
   b. Crank engine until No. 1 cylinder intake valve closes. (Figure 7)
   c. Continue to crank slowly (approx. 1/3-turn) until timing mark on torsional damper lines up with top dead center mark (located on timing tab). (Figure 3)
   d. Install valve cover with new gasket.
2. Place new gasket on distributor pilot.
3. Position distributor pilot in cylinder block so that mark on adaptor housing is toward front of engine. (Figure 1)
4. Position rotor in line with mark on adaptor housing.
5. Turn rotor, as required, to engage distributor gear and camshaft gear so that rotor points toward front of engine.

   NOTE: With No. 1 piston at top dead center of its compression stroke (timing marks aligned), rotor must point toward front of engine when distributor is down in position. It may be necessary to turn engine over with starter, while pressing down on distributor pilot, to engage oil pump shaft.

6. Turn distributor pilot, as required, to line up mark on adaptor with rotor. (Figure 8)
7. Install hold-down clamp and screw.
8. Connect ground wire to intake manifold.
9. Connect trigger leads to switch box, matching color-to-color.
10. Install distributor cap.
11. Install switch box cover.
12. Connect timing light to No. 1 cylinder spark plug and lead wire.

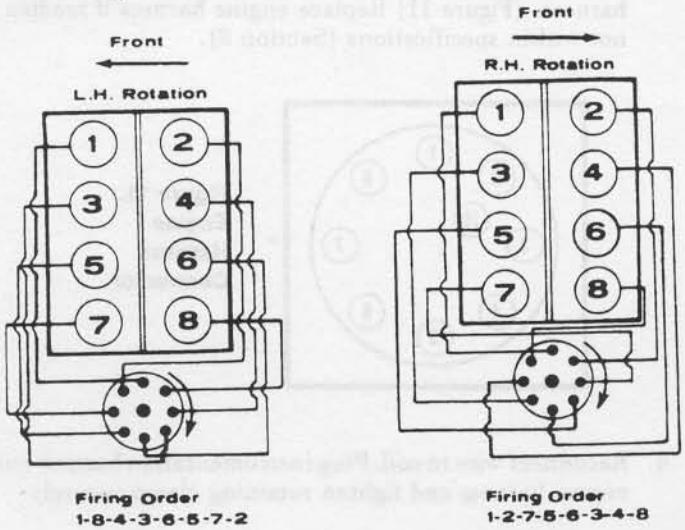


Figure 7. Cylinder Location and Firing Order

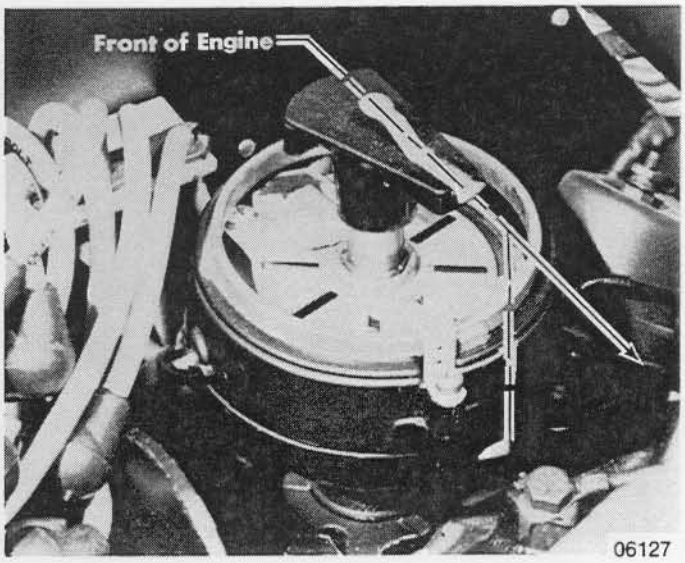


Figure 8. Distributor Rotor and Pilot Position

13. Start engine and run at normal idle.
14. Aim timing light at timing tab.
15. Adjust timing by loosening distributor clamp and rotating distributor, as required, to align timing marks to specification. (Figure 9 or 10)

    NOTE: Timing points in Figures 9 and 10 are for illustration only. See Section 8, "Specifications", for correct timing specification.

16. Tighten clamp screw and recheck timing marks.
17. Stop engine and remove timing light.

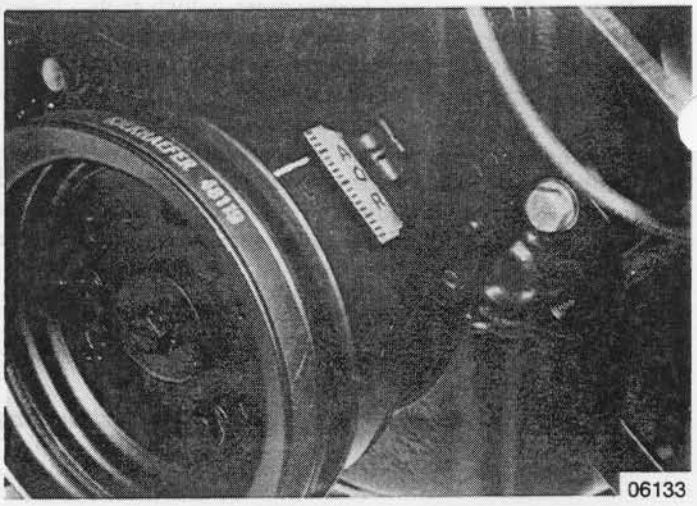


Figure 9. Timing Marks Aligned - 10° BTDC - Left Hand Rotation Engine

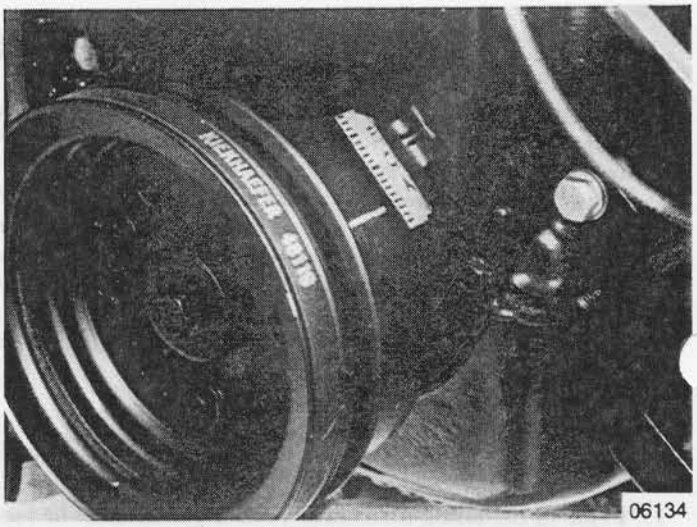


Figure 10. Timing Marks Aligned - 10° BTDC - Right Hand Rotation Engine

TESTING IGNITION RESISTANCE WIRE

ENGINE with ELECTRIC CHOKE HEATER ELEMENT

1. Disconnect wire from positive (+) side of coil. (See Section 3E, "Wiring Diagrams".)
2. Unplug quick disconnect (with 2 wires) from electric choke heater element.
3. Connect ohm meter leads to ends of disconnected wires. Replace engine harness if reading is not within specifications (Section 8).
4. Reconnect wires to coil and choke.

ENGINE without ELECTRIC CHOKE HEATER ELEMENT

1. Disconnect wire from positive (+) side of coil. (See Section 3E, "Wiring Diagrams".)
2. Unplug instrumentation harness from engine harness.
3. Connect one ohm meter lead to wire removed from coil. Connect other ohm meter lead to No. 5 pin hole in engine harness. (Figure 11) Replace engine harness if reading is not within specifications (Section 8).

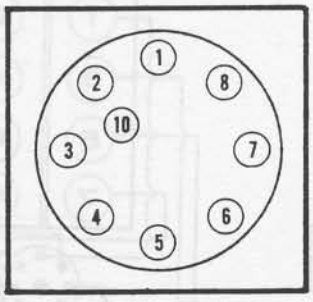


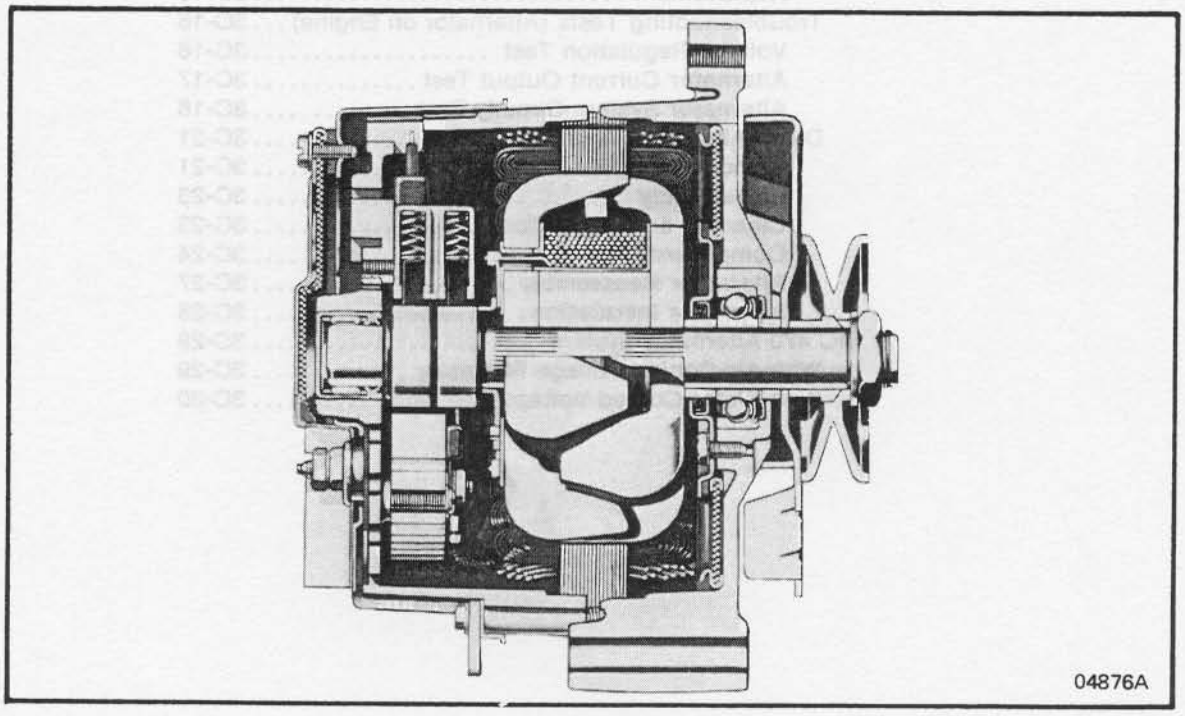
Figure 11. Engine Harness Connector

4. Reconnect wire to coil. Plug instrumentation harness onto engine harness and tighten retaining clamp securely.

SECTION 3 - ELECTRICAL SYSTEM

mercruiser

PART C - ALTERNATOR SYSTEM



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MOTOROLA ALTERNATOR SYSTEM

Description

The alternator system, used on engines with Motorola Alternators (Figure 1), consists of the alternator, battery, ammeter, the ignition switch and the wiring which connects these components. (Figure 2)

The alternator employs a rotor, which is supported in 2 end frames by ball bearings, and is driven (via a pulley) at approximately twice engine speed. The rotor contains a field winding that is enclosed between 2 multiple-finger pole pieces. The ends of the field winding are connected to 2 insulated slip rings on the rotor shaft. Current is supplied to the field winding by 2 brushes (mounted in the rear end frame) which make continuous sliding (or slipping) contact with the slip rings. The current (flowing through the field winding) creates a magnetic field that causes the adjacent fingers of the pole pieces to become alternate north and south magnetic poles.

A 3-phase stator is mounted directly over the rotor pole pieces and between the 2 end frames. It consists of 3 windings wound 120° electrically out-of-phase on the inside of a laminated core. The windings are all connected together on one end, while the other ends are connected to a full-wave rectifier bridge.

The rectifier bridge contains 6 diodes which are arranged so that current flows from ground, thru the stator and to the output terminal, but not in the opposite direction.

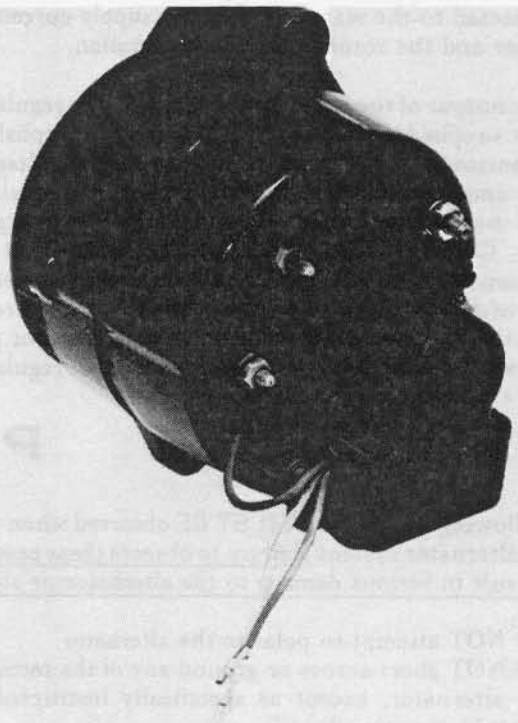

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Figure 1. Motorola Alternator

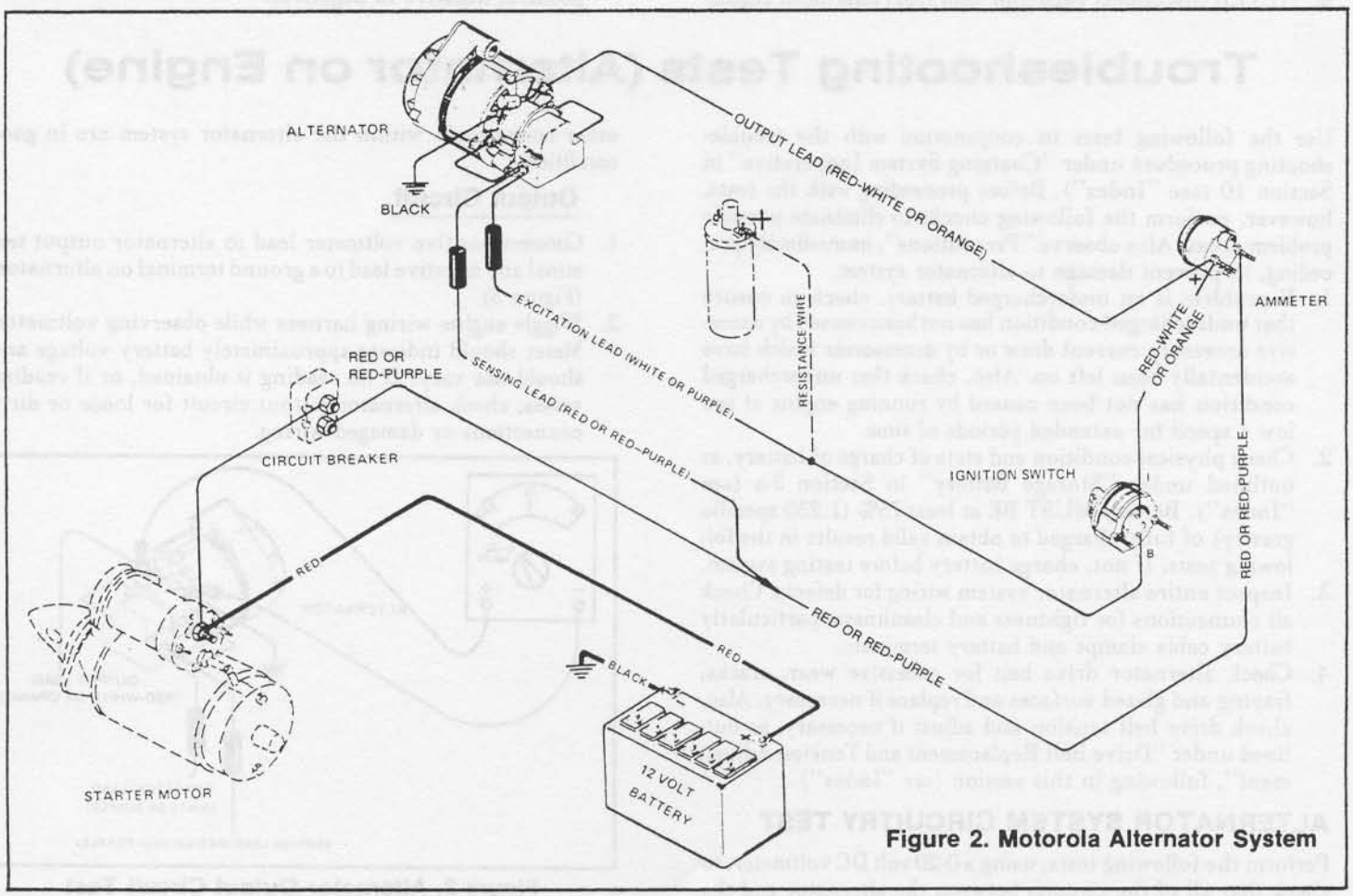


Figure 2. Motorola Alternator System

When current is supplied to the rotor field winding, and the rotor is turned, the movement of the magnetic fields created induces an alternating current into the stator windings. The rectifier bridge then changes this alternating current to direct current which appears at the output terminal. A diode trio also is connected to the stator windings to supply current to the regulator and the rotor field during operation.

Voltage output of the alternator is controlled by regulating the current supplied to the rotor field. This is accomplished by a transistorized voltage regulator that senses the voltage at the battery and regulates the field current to maintain alternator voltage within prescribed limits for properly charging the battery. Current output of the alternator does not require regulation, as maximum current output is self-limited by the design of the alternator. As long as the voltage is regulated within the prescribed limits, the alternator cannot produce excessive current. A cutout relay in the voltage regulator also is not required, as the rectifier diodes (which allow current to flow in one direction only) prevent the battery from discharging back through the stator.

Due to the lack of residual magnetism in the rotor pole pieces, a small amount of current must be supplied to the rotor field to initially start the alternator charging. This is accomplished by means of an excitation circuit in the regulator which is connected to the ignition switch. Once the alternator begins to produce output, field current is supplied solely by the diode trio, as explained, preceding.

The alternator also is equipped with a fan (mounted on the rotor shaft) which induces air flow through the alternator to remove the heat created by the rectifier and stator. A capacitor also is utilized to protect the rectifier system from high voltages and to suppress radio noise.

Precautions

The following precautions MUST BE observed when working on the alternator system. Failure to observe these precautions may result in serious damage to the alternator or alternator system.

1. DO NOT attempt to polarize the alternator.
2. DO NOT short across or ground any of the terminals on the alternator, except as specifically instructed in the "Troubleshooting Tests".
3. NEVER disconnect the alternator output lead or battery cables when the alternator is being driven by the engine.
4. NEVER disconnect regulator lead from alternator regulator terminal when the alternator is being driven by the engine.
5. ALWAYS remove negative (-) battery cable from battery before working on alternator system.
6. When installing battery, BE SURE to connect the negative (-) (grounded) battery cable to negative (-) battery terminal and the positive (+) battery cable to positive (+) battery terminal.
7. If a charger or booster battery is to be used, BE SURE to connect it in parallel with existing battery (positive to positive; negative to negative).

Troubleshooting Tests (Alternator on Engine)

Use the following tests in conjunction with the troubleshooting procedure under "Charging System Inoperative" in Section 10 (see "Index"). Before proceeding with the tests, however, perform the following checks to eliminate possible problem areas. Also observe "Precautions", immediately preceding, to prevent damage to alternator system.

1. If problem is an undercharged battery, check to ensure that undercharged condition has not been caused by excessive accessory current draw or by accessories which have accidentally been left on. Also, check that undercharged condition has not been caused by running engine at too low a speed for extended periods of time.
2. Check physical condition and state of charge of battery, as outlined under "Storage Battery" in Section 3-a (see "Index"). Battery MUST BE at least 75% (1.230 specific gravity) of fully charged to obtain valid results in the following tests. If not, charge battery before testing system.
3. Inspect entire alternator system wiring for defects. Check all connections for tightness and cleanliness, particularly battery cable clamps and battery terminals.
4. Check alternator drive belt for excessive wear, cracks, fraying and glazed surfaces and replace if necessary. Also, check drive belt tension and adjust if necessary, as outlined under "Drive Belt Replacement and Tension Adjustment", following in this section (see "Index").

ALTERNATOR SYSTEM CIRCUITRY TEST

Perform the following tests, using a 0-20 volt DC voltmeter, to check that all of the circuits between the alternator and the other components within the alternator system are in good condition.

Output Circuit

1. Connect positive voltmeter lead to alternator output terminal and negative lead to a ground terminal on alternator. (Figure 3)
2. Wiggle engine wiring harness while observing voltmeter. Meter should indicate approximately battery voltage and should not vary. If no reading is obtained, or if reading varies, check alternator output circuit for loose or dirty connections or damaged wiring.

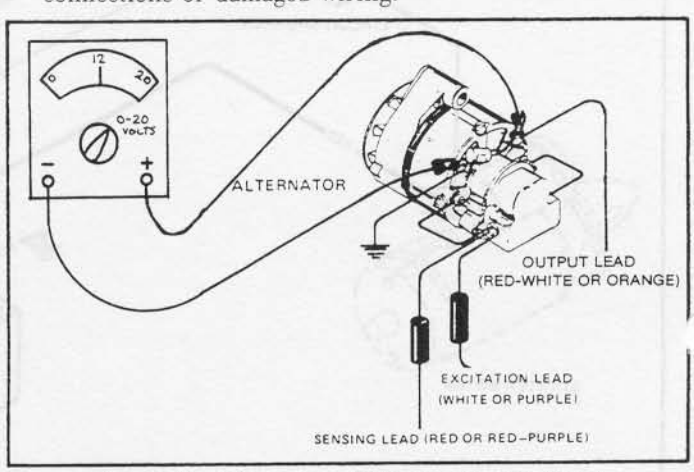


Figure 3. Alternator Output Circuit Test

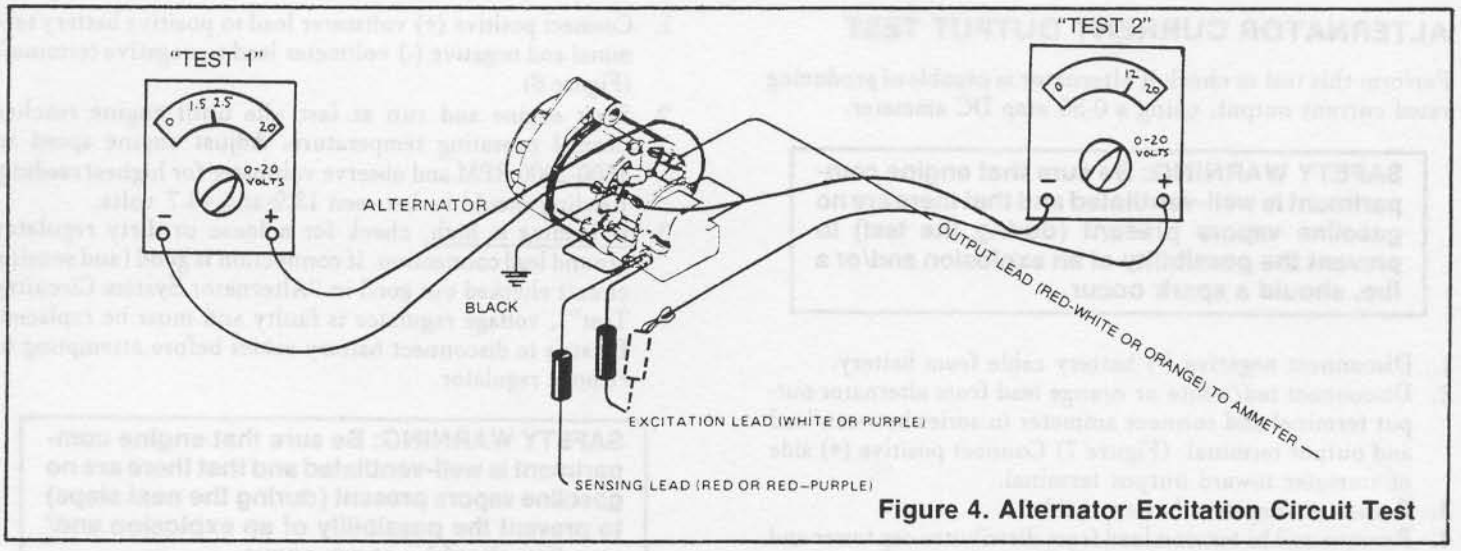
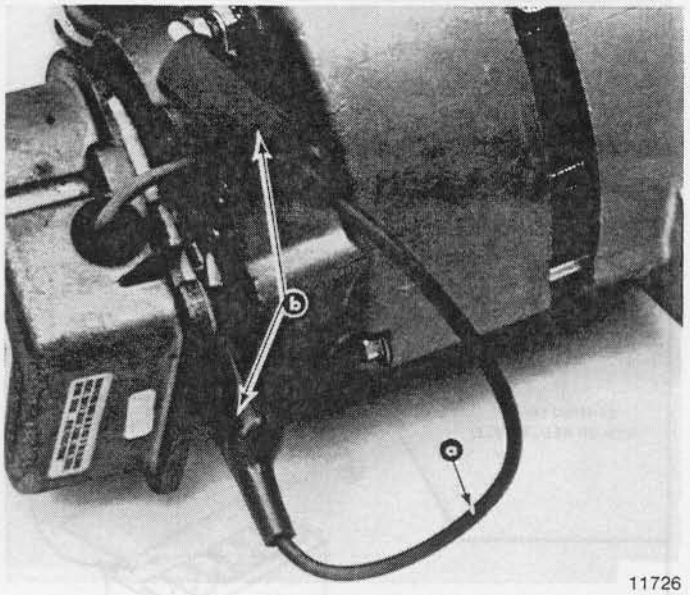


Figure 4. Alternator Excitation Circuit Test

Excitation Circuit

1. Connect positive (+) voltmeter lead to regulator terminal on alternator and negative (–) lead to a ground terminal on alternator. (Test No. 1 in Figure 4)
2. Turn ignition switch to "On" position and note voltmeter reading. Reading should be 1.5 to 2.5 volts.
3. If no reading is obtained, an opening exists in alternator excitation lead or in excitation circuit of regulator. Unplug white or purple lead from regulator. Connect positive voltmeter lead to white or purple lead and negative voltmeter lead to ground. (Test No. 2 in Figure 4) If voltmeter now indicates approximate battery voltage, voltage regulator is defective and must be replaced. If no voltage is indicated, check excitation circuit for loose or dirty connections or damaged wiring.
4. If reading is between .75 and 1.1 volts, rotor field circuit probably is shorted or grounded. Disassemble alternator and test rotor as outlined under "Alternator Repair", following.



a - Jumper Wire Connected between Regulator Terminal and Field (Brush) Terminal
b - Use Insulators to Prevent Wire from Contacting Alternator

Figure 5. Checking for Faulty Regulator Load Circuit

5. If reading is between 6.0 and 7.0 volts, rotor field circuit probably is open. Remove regulator and inspect for worn brushes or dirty slip rings. Replace brushes if less than ¼" (6.35mm) long. If brushes and slip rings are in good condition, disassemble alternator and test rotor, as outlined under "Alternator Repair".
6. If reading is between 8.5 and 10.0 volts, an open probably exists in load circuit of regulator. To be certain that this is the problem, remove 4 screws which secure the regulator to the alternator. Connect a jumper wire between regulator terminal and field (brush) terminal. (Figure 5) DO NOT allow jumper lead to touch alternator housing. Repeat test. If jumper wire provides correct voltmeter reading (1.5 to 2.5 volts), voltage regulator is faulty and must be replaced.

Sensing Circuit

1. Unplug red or red/purple lead from voltage regulator.
2. Connect positive voltmeter lead to red or red/purple lead and negative voltmeter lead to ground terminal. (Figure 6)
3. Voltmeter should indicate battery voltage. If battery voltage is not present, check sensing circuit (red or red/purple lead) for loose or dirty connections or damaged wiring.

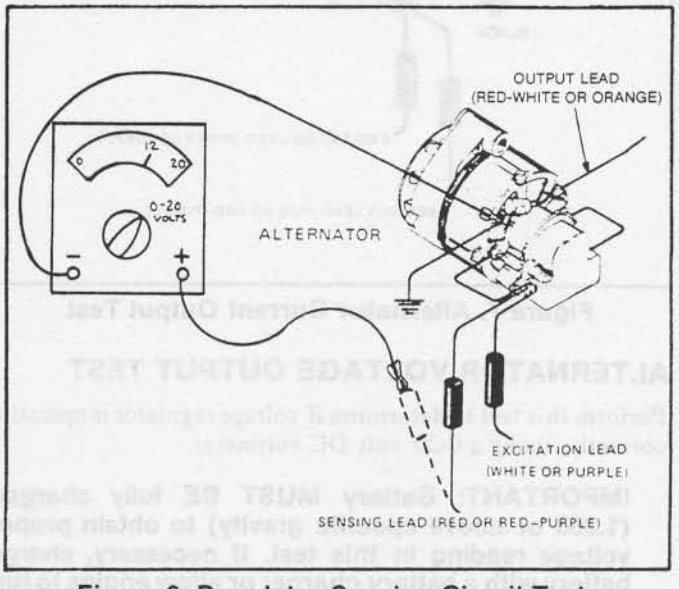


Figure 6. Regulator Sensing Circuit Test

ALTERNATOR CURRENT OUTPUT TEST

Perform this test to check if alternator is capable of producing rated current output, using a 0-50 amp DC ammeter.

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that there are no gasoline vapors present (during the test) to prevent the possibility of an explosion and/or a fire, should a spark occur.

1. Disconnect negative (-) battery cable from battery.
2. Disconnect red/white or orange lead from alternator output terminal and connect ammeter in series between lead and output terminal. (Figure 7) Connect positive (+) side of ammeter toward output terminal.
3. Reconnect negative battery cable.
4. Remove coil hi-tension lead from distributor cap tower and ground it to block. Turn on all accessories and crank engine over with starter motor for 15-20 seconds.
5. Turn off accessories and reinstall coil hi-tension lead. Start engine and adjust engine speed to 1500-2000 RPM. Quickly observe ammeter. Reading should be at least 30 amps.
6. If reading is low, stop engine and connect a jumper wire between alternator output terminal and regulator terminal. (Figure 7) Repeat Steps 4 and 5.
7. If reading is now within specifications, diode trio is faulty. Disassemble alternator and replace diode trio, as explained under "Alternator Repair", following.
8. If reading is still low with jumper wire connected, perform "Voltage Regulator Test", following, to determine if fault is in regulator or alternator.

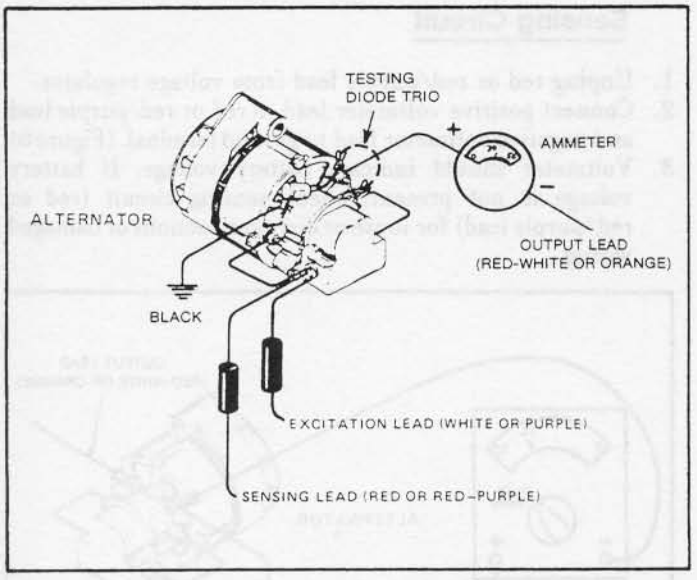


Figure 7. Alternator Current Output Test

ALTERNATOR VOLTAGE OUTPUT TEST

Perform this test to determine if voltage regulator is operating correctly, using a 0-20 volt DC voltmeter.

IMPORTANT: Battery MUST BE fully charged (1.260 or above specific gravity) to obtain proper voltage reading in this test. If necessary, charge battery with a battery charger or allow engine to run a sufficient length of time to fully charge battery before taking reading.

1. Connect positive (+) voltmeter lead to positive battery terminal and negative (-) voltmeter lead to negative terminal. (Figure 8)
2. Start engine and run at fast idle until engine reaches normal operating temperature. Adjust engine speed to 1500-2000 RPM and observe voltmeter for highest reading. Reading should be between 13.9 and 14.7 volts.
3. If reading is high, check for a loose or dirty regulator ground lead connection. If connection is good (and sensing circuit checked out good in "Alternator System Circuitry Test"), voltage regulator is faulty and must be replaced. Be sure to disconnect battery cables before attempting to remove regulator.

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that there are no gasoline vapors present (during the next steps) to prevent the possibility of an explosion and/or a fire, should a spark occur.

CAUTION: DO NOT allow jumper wire to contact alternator end frame (in next step), as diode trio and regulator may be damaged.

4. If reading is low, stop engine and remove 4 regulator attaching screws. Pull regulator away from alternator end frame to gain access to field terminal. DO NOT disconnect regulator leads. Connect a jumper wire between field (brush) terminal and regulator terminal. (Figures 5 and 8) Restart engine and gradually increase engine speed to 1500 RPM while observing voltmeter. DO NOT allow voltage to exceed 16 volts.
5. If a voltmeter reading of 14.5 volts or above is now obtained, voltage regulator is faulty and must be replaced. If voltmeter reading is below 14.5 volts, inspect brushes and slip rings for wear, dirt or damage. If brushes and slip rings are good, alternator is faulty internally. Disassemble alternator and test components, as outlined under "Alternator Repair", following.

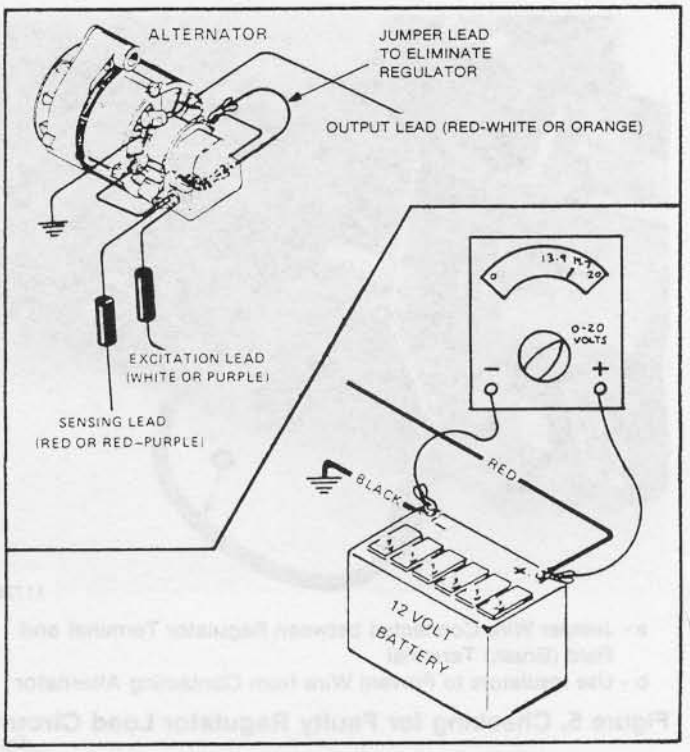
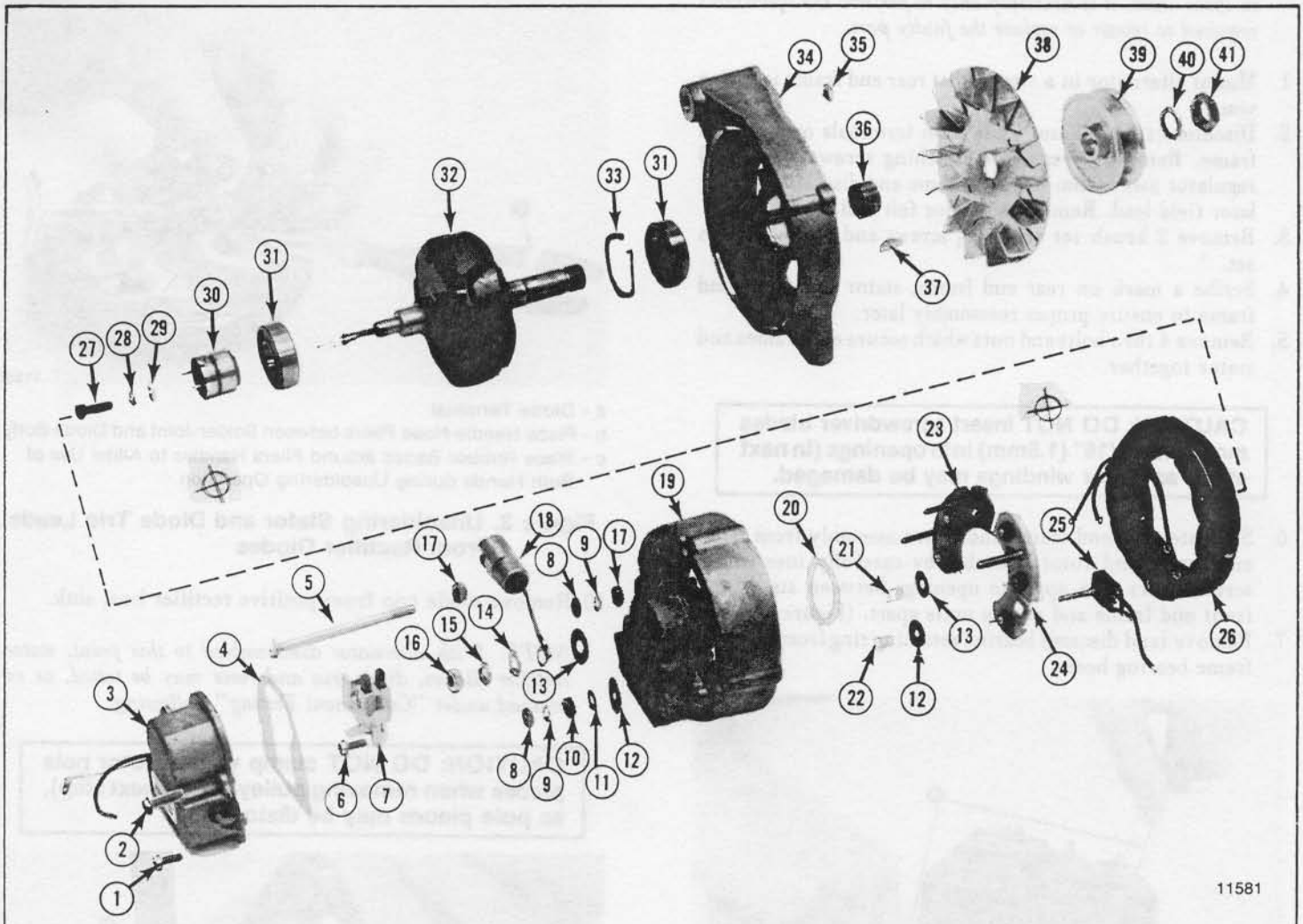


Figure 8. Voltage Regulator Test

Alternator Removal, Repair and Installation

REMOVAL

1. Disconnect negative (-) battery cable from battery.
2. Disconnect wiring harness from alternator.
3. Remove alternator brace to alternator attaching bolt, washer(s) and spacer (if used).
4. Loosen alternator brace to engine attaching bolt and alternator mounting bolt, then pivot alternator inward and remove alternator drive belt.
5. Remove alternator mounting bolt, washers (if used), spacer and nut and remove alternator.



1 - Regulator Attaching Screw - Short (2)
2 - Regulator Attaching Screw - Long (2)
3 - Regulator
4 - Regulator Felt Seal
5 - Thru Bolt (4)
6 - Brush Set Attaching Screw (2)
7 - Brush Set
8 - Regulator Lead Attaching Nut (2)
9 - Regulator Lead Attaching Lockwasher (2)
10 - Diode Trio Attaching Nut (Self-Locking)
11 - Diode Trio Attaching Flat Washer
12 - Diode Trio Insulating Washer (2)
13 - Positive Rectifier Diode Set Insulating Washer (2)
14 - Positive Rectifier Diode Set Attaching Flat Washer
15 - Positive Rectifier Diode Set Attaching Lockwasher
16 - Positive Rectifier Diode Set Attaching Nut
17 - Negative Rectifier Diode Set Attaching Nut (Self-Locking) (2)
18 - Condenser
19 - Rear End Frame
20 - Rear End Frame Bearing Retainer
21 - Positive Rectifier Diode Set Mounting Stud Insulator
22 - Diode Trio Mounting Stud Insulator
23 - Negative Rectifier Diode Set
24 - Positive Rectifier Diode Set
25 - Diode Trio
26 - Stator
27 - Slip Ring Attaching Screw
28 - Slip Ring Attaching Lockwasher
29 - Slip Ring Attaching Flat Washer
30 - Slip Ring
31 - Rotor Bearing (2)
32 - Rotor
33 - Front End Frame Bearing Retaining Ring
34 - Front End Frame
35 - Thru Bolt Securing Nut (4)
36 - Fan Spacer
37 - Rotor Shaft Key
38 - Fan (Bi-Directional Shown)
39 - Pulley
40 - Pulley Attaching Lockwasher
41 - Pulley Attaching Nut

Figure 1. Motorola Alternator (B-78402 and B-78403) Exploded Parts View

DISASSEMBLY

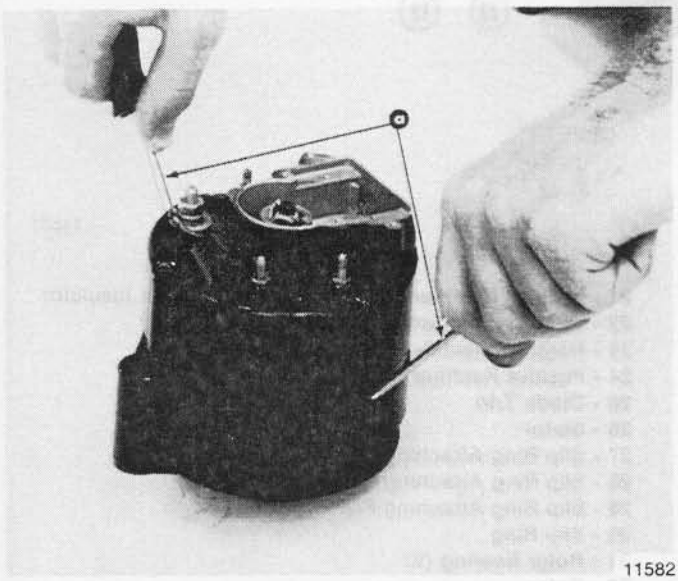
(Refer to Exploded Parts View in Figure 1 on preceding page for Parts Identification.)

NOTE: The following instructions are for complete disassembly and overhaul of the alternator. In many cases, however, complete disassembly of alternator is not required and, in those cases, it is necessary only to perform the operations required to repair or replace the faulty part.

1. Mount alternator in a vise so that rear end frame is facing you.
2. Disconnect 2 regulator leads from terminals on rear end frame. Remove 4 regulator attaching screws, then pull regulator away from rear end frame and disconnect regulator field lead. Remove regulator felt seal.
3. Remove 2 brush set attaching screws and remove brush set.
4. Scribe a mark on rear end frame, stator and front end frame to ensure proper reassembly later.
5. Remove 4 thru bolts and nuts which secure end frames and stator together.

CAUTION: DO NOT insert screwdriver blades more than 1/16" (1.6mm) into openings (in next step), as stator windings may be damaged.

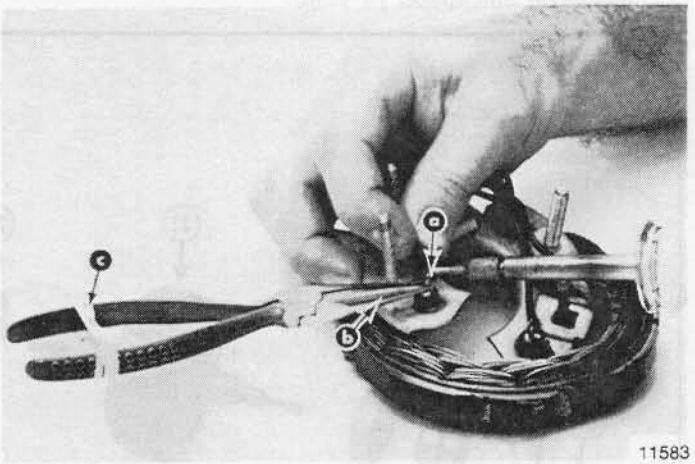
6. Separate rear end frame and stator assembly from front end frame and rotor assembly by carefully inserting 2 screwdrivers into opposite openings between stator and front end frame and prying units apart. (Figure 2)
7. Remove (and discard) bearing retaining ring from rear end frame bearing bore.



a - DO NOT Insert Screwdriver Blades More Than 1/16" into Openings

Figure 2. Separating Rear End Frame and Stator Assembly from Front End Frame and Rotor Assembly

8. Place rear end frame and stator assembly on the bench with stator downward. Be sure that bench is clean and free of metal chips. Remove nuts, washers, insulators and condenser from rectifier mounting studs and lift rear end frame from studs. Remove 2 insulating sleeves and washers from rectifier studs.
9. Unsolder stator and diode trio leads from rectifier diode terminals. Place a needle-nose pliers on diode terminal between solder joint and diode body (as shown in Figure 3) to help prevent heat damage to diodes. Unsolder joints as quickly as possible and allow diode terminal to cool before removing pliers.



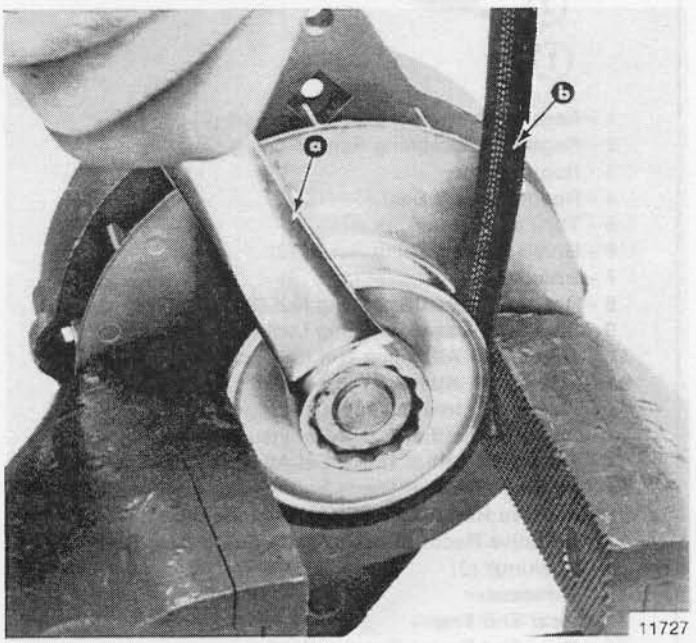
a - Diode Terminal
b - Place Needle-Nose Pliers between Solder Joint and Diode Body
c - Place Rubber Bands around Pliers Handles to Allow Use of Both Hands during Unsoldering Operation

Figure 3. Unsoldering Stator and Diode Trio Leads from Rectifier Diodes

10. Remove diode trio from positive rectifier heat sink.

NOTE: With alternator disassembled to this point, stator, rectifier diodes, diode trio and rotor may be tested, as explained under "Component Testing", following.

CAUTION: DO NOT clamp vise on rotor pole pieces when removing pulley nut (in next step), as pole pieces may be distorted.



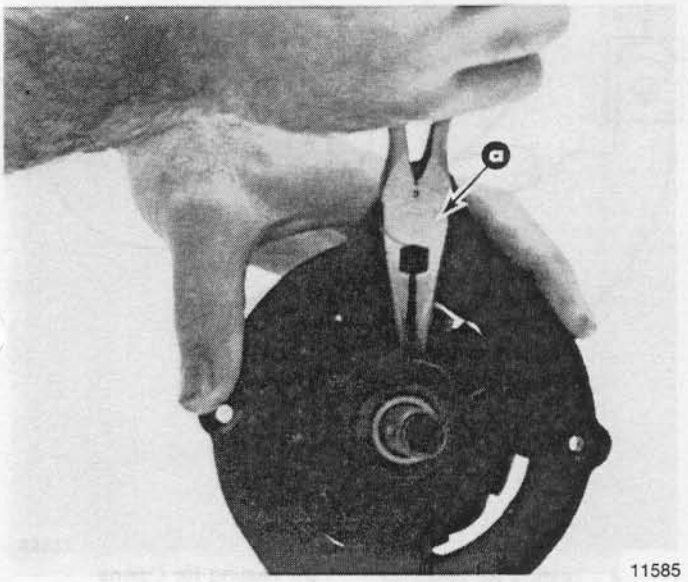
a - 15/16" Wrench
b - Use Oversize V-Belt to Protect Pulley

Figure 4. Removing Pulley Nut

11. Remove pulley retaining nut by clamping pulley in a vise (using an old oversize V-belt or protective jaws to protect pulley) and turning nut counterclockwise with a 15/16" wrench. (Figure 4) Remove lockwasher and slide pulley and fan from shaft. If pulley is "stubborn", it may be necessary to use an universal pullers.
12. Remove key from rotor shaft with a diagonal pliers, then slide fan spacer from shaft.

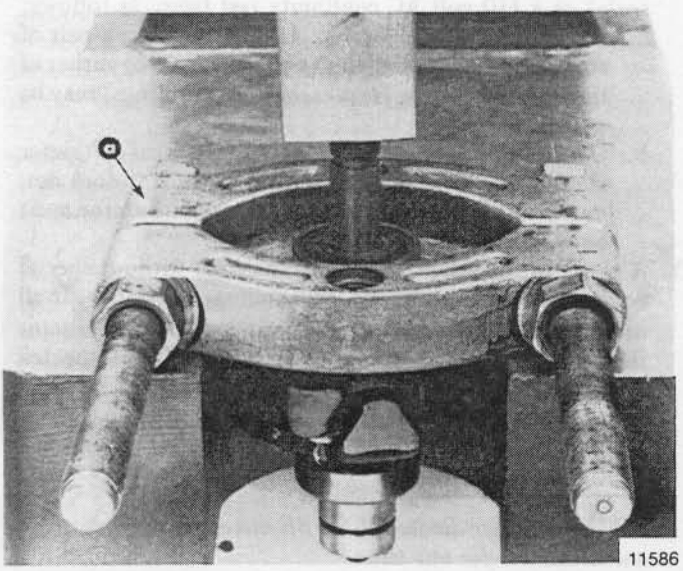
IMPORTANT: DO NOT remove front end frame from rotor shaft, unless absolutely necessary, as front bearing MUST BE replaced, if it is removed.

13. Using a long-nose pliers, compress ears of front bearing retainer and lift retainer free of recess in front end frame. (Figure 5) Tap pulley end of rotor shaft with a rawhide mallet to remove rotor and front bearing assembly from front end frame.
14. Remove front bearing from rotor shaft with Universal Puller Plate (C-91-37241) or equivalent and an arbor press, as shown in Figure 6. (Discard bearing.)



a - Compress Ears of Retainer and Lift

Figure 5. Removing Front Bearing Retainer from Recess



a - Universal Puller Plate (C-91-37241)

Figure 6. Removing Front Bearing from Rotor Shaft

15. If rotor slip rings or rear bearing require replacement, carefully unsolder rotor field winding leads from slip ring terminals and unwind end of leads. Remove slip ring attaching screw, lockwasher and flat washer and slide slip rings from shaft.
16. If rear bearing requires replacement, remove bearing from rotor shaft with Universal Puller Plate and arbor press. Bearing MUST BE replaced, if removed.

CLEANING and INSPECTION

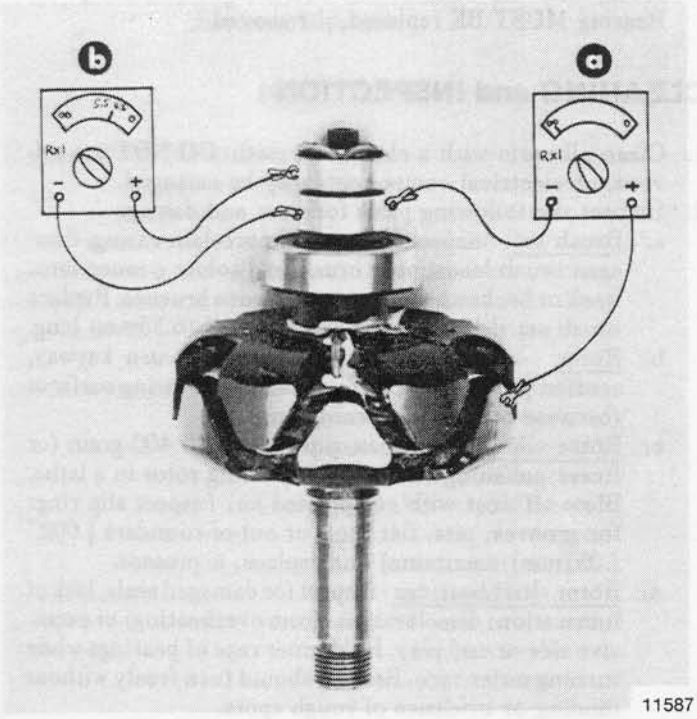
1. Clean all parts with a clean, soft cloth. DO NOT use solvent, or electrical components may be damaged.
2. Inspect the following parts for wear and damage:
   a. Brush set - inspect for cracked porcelain casing, damaged brush leads, poor brush lead solder connections, weak or broken brush springs or worn brushes. Replace brush set if brushes are less than ¼" (6.35mm) long.
   b. Rotor - inspect for stripped threads, worn keyway, scuffed pole piece fingers or damaged bearing surfaces (because of bearing turning on shaft).
   c. Rotor slip rings - clean slip rings with 400 grain (or finer) polishing cloth while spinning rotor in a lathe. Blow off dust with compressed air. Inspect slip rings for grooves, pits, flat spots or out-of-rounders [.002" (.051mm) maximum] and replace, if present.
   d. Rotor shaft bearings - inspect for damaged seals, lack of lubrication, discoloration (from overheating) or excessive side or end play. Hold inner race of bearings while turning outer race. Bearing should turn freely without binding or evidence of rough spots.
   e. Stator - inspect for damaged insulation or wires; also inspect insulating enamel for heat discoloration, as this is usually a sign of a shorted or grounded winding or a shorted diode.
   f. Regulator - inspect leads for damaged insulation.
   g. Front and rear end frames - inspect for cracks, distortion, stripped threads or wear in bearing bore (from bearing outer race spinning in bore). End frame(s) MUST BE replaced, if bearing has spun. Also, inspect bearing retainer recess in front end frame for damage.
   h. Fan - inspect for cracked or bent fins, broken welds (bi-directional fan only) or worn mounting hole (from fan spinning on shaft).
   i. Pulley - inspect pulley mounting bore and key groove for wear. Inspect drive surface of pulley sheaves for trueness, excessive wear, grooves, pits, nicks or corrosion. Repair damaged surfaces, if possible, with a fine file and a wire brush or replace pulley, if beyond repair. Drive surfaces MUST BE perfectly true and smooth, or drive belt wear will be greatly accelerated.

COMPONENT TESTING

Rotor

1. Test rotor field circuit for grounds, using an ohmmeter (set on Rx1 scale) or a 110 volt AC continuity test lamp, as follows:
   a. Connect one lead of ohmmeter or test lamp to either slip ring and the other lead to rotor shaft or pole pieces. (Figure 7)
   b. Meter or test lamp should indicate no continuity (meter should not move; lamp should not illuminate).
   c. If continuity does exist, rotor field circuit is grounded. Inspect slip ring terminals to be sure that they are not bent and touching rotor shaft. Also be sure that excess

solder is not grounding terminals to rotor shaft. If cause for ground cannot be found, unsolder field winding leads from slip ring terminals and connect ohmmeter between one of the leads and rotor shaft or pole pieces. If continuity still exists, replace rotor assembly. If continuity is eliminated, replace slip rings.



11587

a - Test for Grounds
b - Test for Opens, Shorts or High Resistance

Figure 7. Testing Rotor Field Circuit

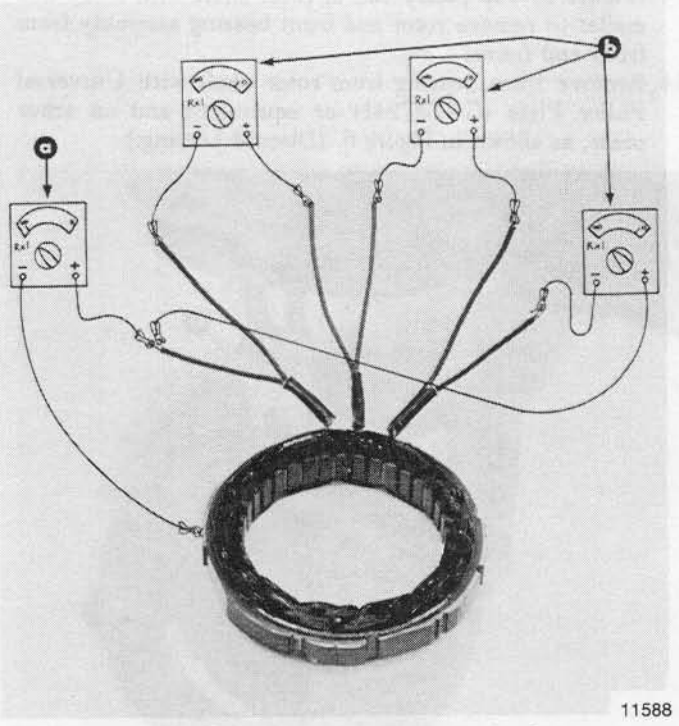
2. Test rotor field circuit for opens, shorts or high resistance, using an ohmmeter (set on Rx1 scale), as follows:
   a. Connect one ohmmeter lead to each slip ring. (Figure 7)
   b. Ohmmeter reading should be 4.2 to 5.5 ohms with rotor at room temperature [70°-80° F (21°-26° C)].
   c. If reading is high or infinite (no meter movement), high resistance or an open exists in the field circuit. Check for poor connections between field winding leads and slip ring terminals. If cause for open or high resistance cannot be found, connect ohmmeter directly to slip ring terminals. If correct reading is now obtained, replace slip rings. If reading is still high or infinite, replace complete rotor assembly.
   d. If reading is low, a short exists in the field circuit. Inspect slip rings to be sure that they are not bent and touching outer slip ring. Also be sure that excess solder is not shorting terminals to aft slip ring. If cause for short cannot be found, unsolder field winding leads from slip ring terminals and connect ohmmeter directly to leads. If correct reading is now obtained, slip rings are shorted and must be replaced. If reading is still low, rotor field windings are shorted, and complete rotor assembly must be replaced.

NOTE: If alternator has output at low speeds, but no output at high speeds, rotor field winding may be shorting or grounding out, because of centrifugal force. Replace rotor, if all other electrical components test good.

Stator

NOTE: Stator leads MUST BE disconnected from rectifier diodes and diode trio for this test.

1. Test stator for grounds, using an ohmmeter (set on Rx1 scale) or a 110 volt AC continuity test lamp, as follows:
   a. Connect one lead of ohmmeter or test lamp to one of the stator leads and the other lead to stator frame. (Figure 8) Be sure that lead makes good contact with frame.
   b. Meter or test lamp should indicate no continuity (meter should not move; lamp should not illuminate). If continuity does exist, stator is grounded and must be replaced.



11588

a - Testing for Grounds b - Testing for Opens

Figure 8. Testing Stator

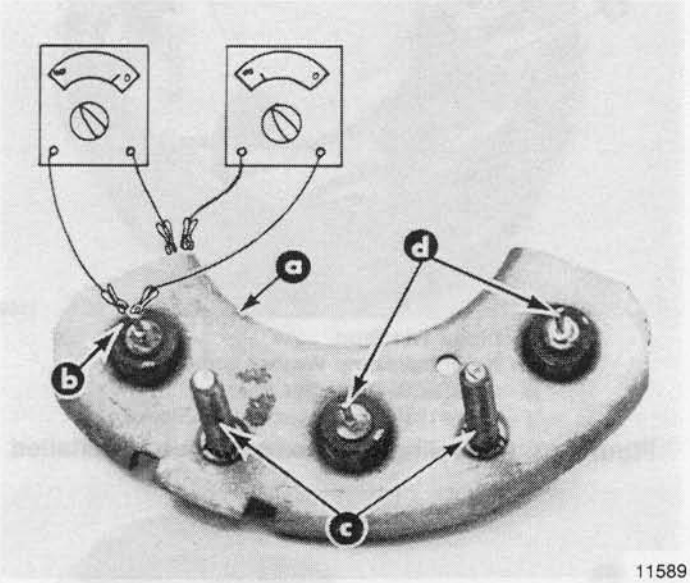
2. Test for opens in stator, using an ohmmeter (set on Rx1 scale) or a 110 volt AC continuity test lamp, as follows:
   a. Connect ohmmeter or test lamp between each pair of stator windings (3 different ways). (Figure 8) Either of the 2 leads (coming from each stator windings) may be used.
   b. Continuity should be present in all 3 cases (meter should move; lamp should illuminate). If it does not, one or more of the windings are open and stator must be replaced.
3. A short in the stator is difficult to detect without special equipment, because of the low windings resistance. If all other electrical components test out good, and alternator fails to produce rated output, stator probably is shorted and should be replaced. Also, examine stator for heat discoloration, as this usually is a sure sign of a short.

Rectifier Diodes

NOTE: Rectifier diodes MUST BE disconnected from stator and diode trio for this test.

CAUTION: DO NOT use a test instrument with more than a 12-volt source (in the following test), as rectifier diodes may be damaged.

1. Connect one lead of an ohmmeter (set on Rx1 scale) to rectifier diode heat sink and the other lead to one of the rectifier diode terminals. (Figure 9) Note the reading. DO NOT connect ohmmeter lead to mounting stud(s).
2. Reverse test leads and again note reading.
3. Meter should indicate a high or infinite resistance (no meter movement) when connected one way and a low reading when connected the other. If both readings are high or infinite, diode is open. If both readings are low, diode is shorted.
4. Repeat Steps 1-thru-3 for 2 other rectifier diodes in heat sink. Also, test other rectifier diode set in same manner.
5. Replace complete rectifier set, if any one of the diodes is shorted or open.



11589

a - Heat Sink
b - Diode Terminal
c - Do Not Connect Lead to Studs
d - Test These 2 Diodes in Same Manner

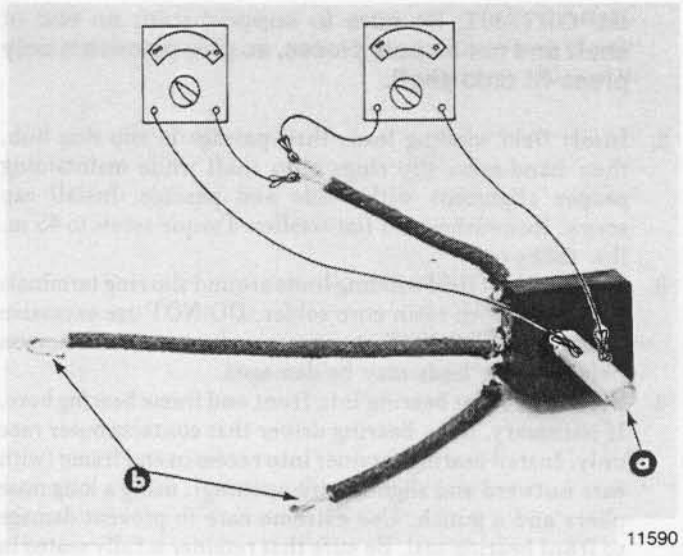
Figure 9. Testing Rectifier Diodes for Shorts or Opens (Negative Rectifier Diode Set Shown)

Diode Trio

NOTE: Diode trio leads MUST BE disconnected from rectifier diodes and stator leads for this test.

CAUTION: DO NOT use a test instrument with more than a 12-volt source (in the following test), as rectifier diodes may be damaged.

1. Connect one lead of an ohmmeter (set on Rx1 scale) to diode trio stud and the other lead to one of the diode trio leads. (Figure 10) Note ohmmeter reading.
2. Reverse ohmmeter leads and again note reading.
3. Meter should indicate a high or infinite reading (no meter movement) when meter is connected one way and a low reading when meter is connected the other way. If both readings are high, diode (in diode trio) is open. If both readings are low, diode is shorted.
4. Repeat Steps 1-thru-3 between diode trio stud and each of the other 2 leads.
5. Replace diode trio if any of the diodes is shorted or open.



11590

a - Stud
b - Repeat Test between These Leads and Stud

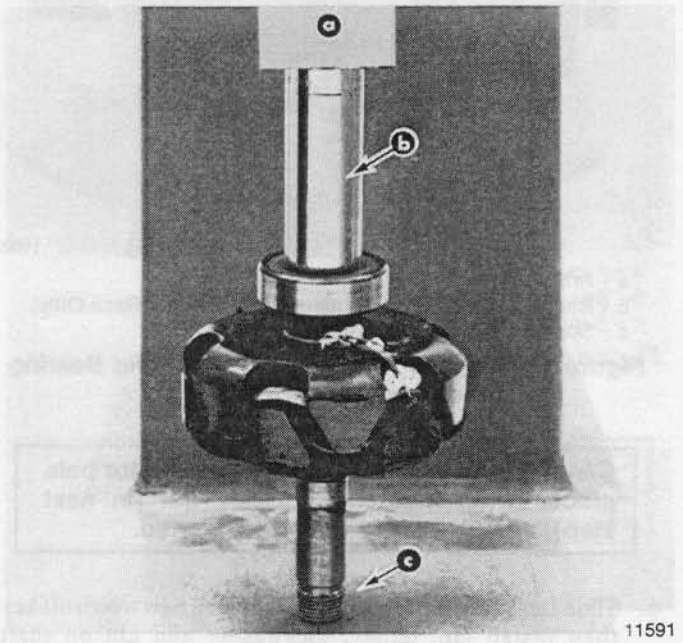
Figure 10. Testing Diode Trio for Shorts or Opens

Condenser

1. Using Magneto Analyzer (C-91-25213 or C-91-31800) and accompanying instructions, perform the following condenser tests:
   a. Condenser Capacity Test (must be .5 mfd)
   b. Condenser Short or Leakage Test
   c. Condenser Series Resistance Test
2. Replace condenser, if test results are not within specifications.

ALTERNATOR REASSEMBLY

1. Press new rear bearing all-the-way onto rotor shaft (until inner race contacts shoulder) with an arbor press and a bearing driver that contacts inner bearing race only, as shown in Figure 11. Use extreme care to prevent damage to field winding leads.



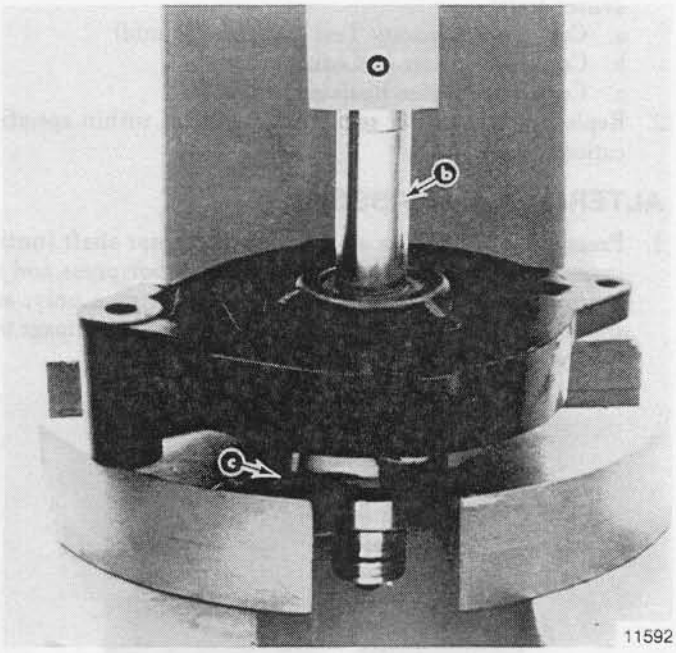
11591

a - Arbor Press
b - Bearing Driver (Must Contact Inner Bearing Race Only)
c - Support Pulley End of Shaft on Arbor Press Base (DO NOT Support Rotor on Pole Pieces)

Figure 11. Installing Rear Bearing on Rotor Shaft

IMPORTANT: Be sure to support rotor on end of shaft and not on pole pieces, as pole pieces are only press-fit onto shaft.

2. Insert field winding leads thru passage in slip ring hub, then hand-press slip rings onto shaft while maintaining proper alignment with leads and passage. Install cap screw, lockwasher and flat washer. Torque screw to 45 in. lbs. (52kg-cm).
3. Wrap ends of field winding leads around slip ring terminals and solder with rosin core solder. DO NOT use excessive solder. Also, DO NOT use excessive heat, or insulation on field winding leads may be damaged.
4. Press new front bearing into front end frame bearing bore. If necessary, use a bearing driver that contacts outer race only. Install bearing retainer into recess in end frame (with ears outward and aligned with opening), using a long nose pliers and a punch. Use extreme care to prevent damage to front bearing seal. Be sure that retainer is fully seated in groove (ears should touch both sides of recess).
5. Press front end frame and bearing assembly onto rotor shaft (until inner bearing race contacts shoulder) with an arbor press and a bearing driver that fits over shaft and contacts inner bearing race only, as shown in Figure 12. Be sure to support rotor on pole pieces only.

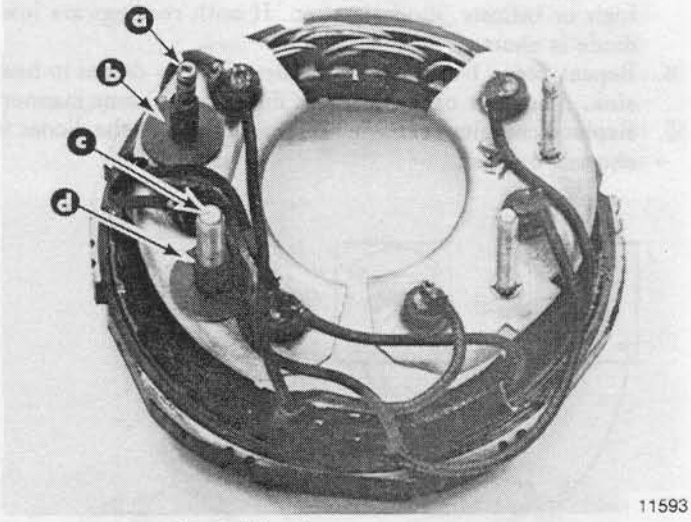


a - Arbor Press
b - Bearing Driver (Must Contact Inner Bearing Race Only)
c - Support Rotor on Pole Pieces

Figure 12. Installing Front End Frame and Bearing Assembly on Rotor Shaft

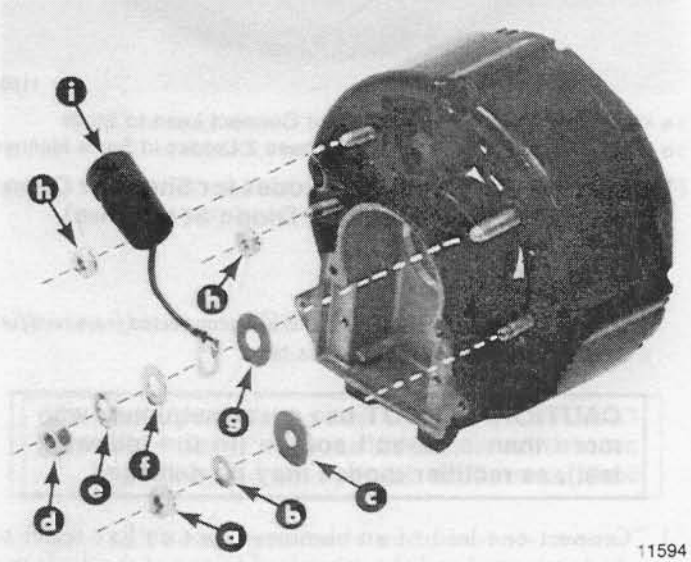
CAUTION: DO NOT clamp vise on rotor pole pieces when tightening pulley nut (in next step), or pole pieces may be distorted.

6. Slide fan spacer onto rotor shaft. Install new woodruff key, then install fan, pulley, lockwasher and nut on shaft. Clamp pulley in a vise, using protective jaws or an old oversize V-belt to protect pulley (Figure 4), and torque nut to 35 to 50 ft. lbs. (4.8 to 6.9mkg). Tighten vise only enough to allow tightening of nut, as excessive tightening may distort pulley.
7. Position diode trio in positive rectifier set heat sink. Using rosin core solder, resolder stator and diode trio leads to rectifier diodes, as shown in Figure 13. Use long-nose pliers to prevent heat damage to diodes. Solder connections as quickly as possible and allow them to cool before removing pliers.
8. Place insulating washers and sleeves on diode trio stud and positive rectifier set stud, as shown in Figure 13.
9. Guide rear end frame onto diode trio and rectifier diode set studs, then install condenser, insulating washers, flat washers, lockwashers and nuts, as shown in Figure 14. Tighten nuts to 20-30 in. lbs.



a - Diode Trio Stud
b - Small Insulating Washer and Sleeve
c - Positive Rectifier Set Stud
d - Large Insulating Washer and Sleeve

Figure 13. Insulating Washer and Sleeve Installed

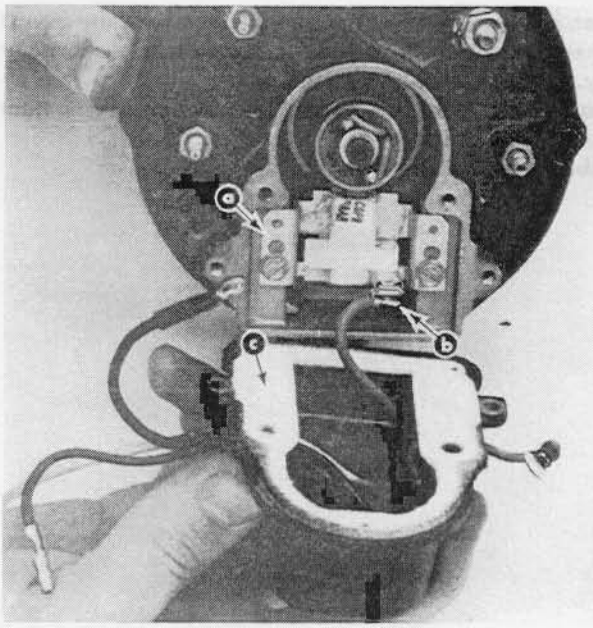


a - Self-Locking Nut (Diode Trio Stud)
b - Flat Washer
c - Insulating Washer
d - Nut (Positive Rectifier Diode Set Stud)
e - Lockwasher
f - Flat Washer
g - Insulating Washer
h - Self-Locking Nuts (Negative Rectifier Diode Set Studs)
i - Condenser

Figure 14. Attaching Rear End Frame to Rectifier Diode Sets and Diode Trio

10. Install new rear bearing retainer in recess in rear end frame bearing bore. Lubricate exposed surface of retainer with a small amount of hydraulic brake fluid to ease assembly over the rear bearing. DO NOT use oil or grease.
11. Position rear end frame and stator assembly over front end frame and rotor assembly and align scribe marks on each (scribed during disassembly). Hand-press end frames together, then install thru bolts and square nuts. Torque bolts EVENLY to 50-60 in. lbs. (58-69kg-cm).
12. Place brush set in rear end frame cavity and secure with 2 mounting screws, as shown in Figure 15. Be sure to use outer-most mounting holes. Torque screws to 16-20 in. lbs. (18-23kg-cm).
13. Position felt seal on regulator mounting surface. Connect regulator field lead to brush terminal (shown in Figure 15), then mount regulator with 4 screws. Torque screws to 40-45 in. lbs. (46-52kg-cm). Connect regulator leads to regulator terminal and ground terminal and secure with lockwashers and nuts. Torque nuts to 20-30 in. lbs. (23-35 kg-cm).

CAUTION: Regulator field lead MUST BE connected as shown in Figure 15, or lead may be damaged by rotor slip rings during operation.



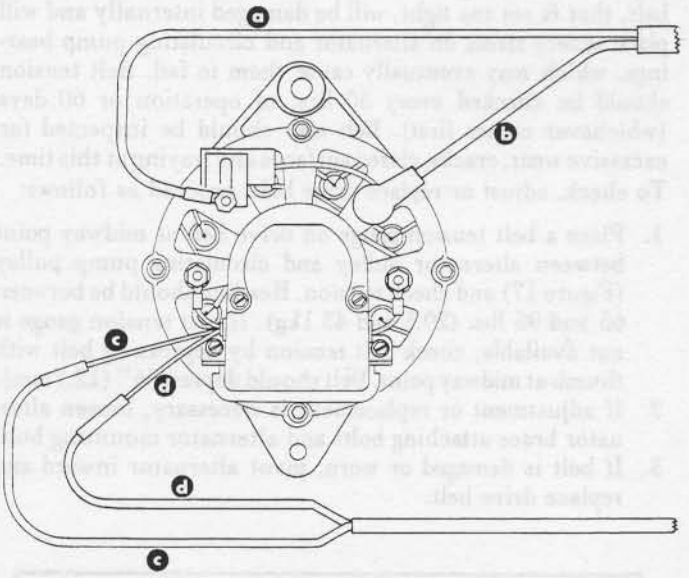
11595

a - Brush Set (Use Outer Mounting Holes)
b - Be Sure to Connect Field Lead as Shown
c - Regulator Felt Seal

Figure 15. Installing Brush Set and Regulator

ALTERNATOR INSTALLATION

1. Position alternator in mounting bracket and install mounting bolt, washers (if used), spacer and nut. Place washers (if used) on each side of spacer. DO NOT tighten nut securely at this time.



a - Black
b - Red-White or Orange
c - White or Purple
d - Red or Red-Purple

Figure 16. Wiring Harness Connected to Alternator

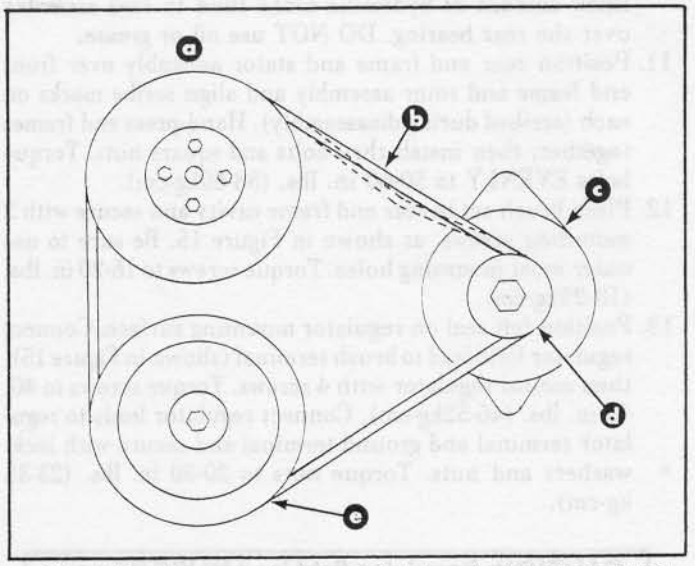
2. Fasten alternator brace to alternator with bolt, washers and spacer (if used). DO NOT tighten bolt at this time.
3. Position alternator drive belt on pulleys and adjust tension as explained under "Drive Belt Replacement and Tension Adjustment", following.
4. Reconnect wiring harness to alternator (Figure 16) and negative battery cable to battery.

Drive Belt Replacement and Tension Adjustment

Drive belt MUST BE in good condition and properly adjusted to achieve proper alternator and circulating pump operation. A loose belt will slip, thus causing excessive belt wear, noise, engine overheating and low or unsteady alternator output. A belt, that is set too tight, will be damaged internally and will place severe stress on alternator and circulating pump bearings, which may eventually cause them to fail. Belt tension should be checked every 50 hrs. of operation or 60 days (whichever comes first). Belt also should be inspected for excessive wear, cracks, glazed surfaces and fraying at this time. To check, adjust or replace drive belt, proceed as follows:

1. Place a belt tension gauge on drive belt at midway point between alternator pulley and circulating pump pulley (Figure 17) and check tension. Reading should be between 65 and 95 lbs. (29.5 and 43.1kg). If belt tension gauge is not available, check belt tension by depressing belt with thumb at midway point. Belt should depress ½" (12.7mm).
2. If adjustment or replacement is necessary, loosen alternator brace attaching bolts and alternator mounting bolt.
3. If belt is damaged or worn, pivot alternator inward and replace drive belt.

CAUTION: When adjusting drive belt tension (in next step), DO NOT apply pressure to alternator rear end frame, as alternator may be damaged.



a - Circulating Pump Pulley
b - Check Point
c - Alternator
d - Alternator Pulley
e - Crankshaft Pulley

Figure 17. Checking Drive Belt Tension

4. Pivot alternator outward, as required, to obtain correct belt tension. Apply pressure to alternator front end frame only. Set new belts at high reading.
5. Retighten alternator brace attaching bolts and alternator mounting bolt securely.
6. Recheck drive belt tension.

DELCO ALTERNATOR SYSTEM

Description

Two basic types of Delco internally-regulated alternators are in use on MerCruiser Engines: (1) The 1-wire alternator (Figure 1) and (2) the 3-wire alternator (Figure 2).

NOTE: Reference to number of wires does not include ground wire.

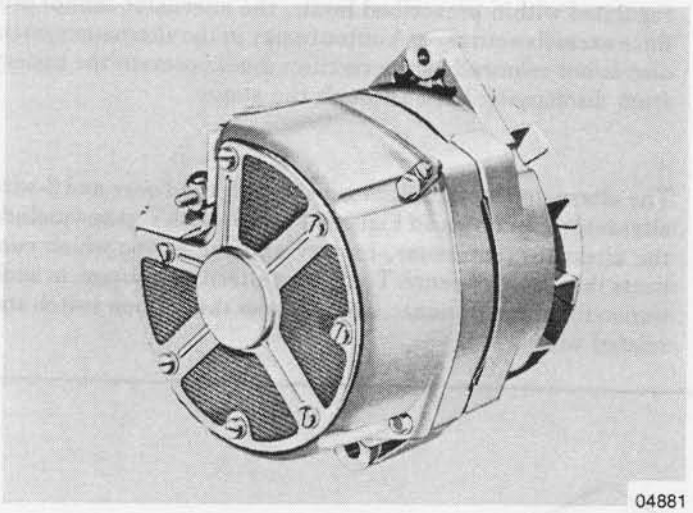


Figure 1. Delco 1-Wire Alternator

Both the 1-wire and 3-wire alternators are very similar in construction and operation, with the exception of the voltage regulator. (Refer to Figure 3.) Each employs a rotor that is supported in 2 end frames by bearings and is driven by a pulley at approximately twice engine speed. The rotor contains a field winding that is encased between 2 multiple finger pole pieces. Both ends of the field winding are connected to 2 insulated slip rings that are mounted on the rotor shaft. Current is supplied to the field winding by 2 brushes (mounted in the slip ring end frame) which make continuous slipping contact with the slip rings. The current flow through the field winding creates a magnetic field that causes the adjacent fingers of the pole pieces to become alternate north and south poles.

A 3-phase stator is mounted directly over the rotor pole pieces and between the 2 end frames. It consists of 3 windings wound 120° electrically out-of-phase on the inside of a laminated core. The windings are all connected together on one end while the other ends are connected to a full-wave rectifier bridge. The rectifier bridge contains 6 diodes which are arranged in such a manner that it allows current to flow from ground, thru the stator and to the battery ("BAT") terminal, but not in the opposite direction. When current is supplied to the rotor field winding (source to be explained later), and the rotor is turned, the movement of the field induces an alternating current into the stator windings. The rectifier bridge then changes this current to direct current which appears at the battery ("BAT") terminal. A diode trio also is connected to the stator windings and to the rectifier bridge which supplies current to the rotor field winding during operation.

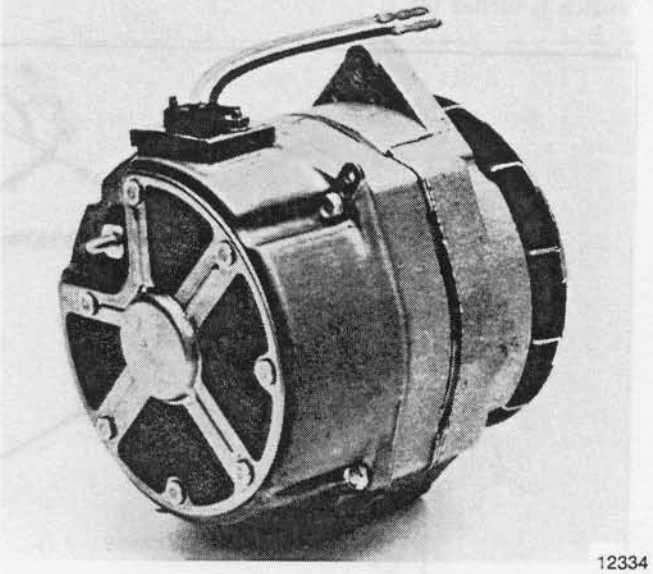
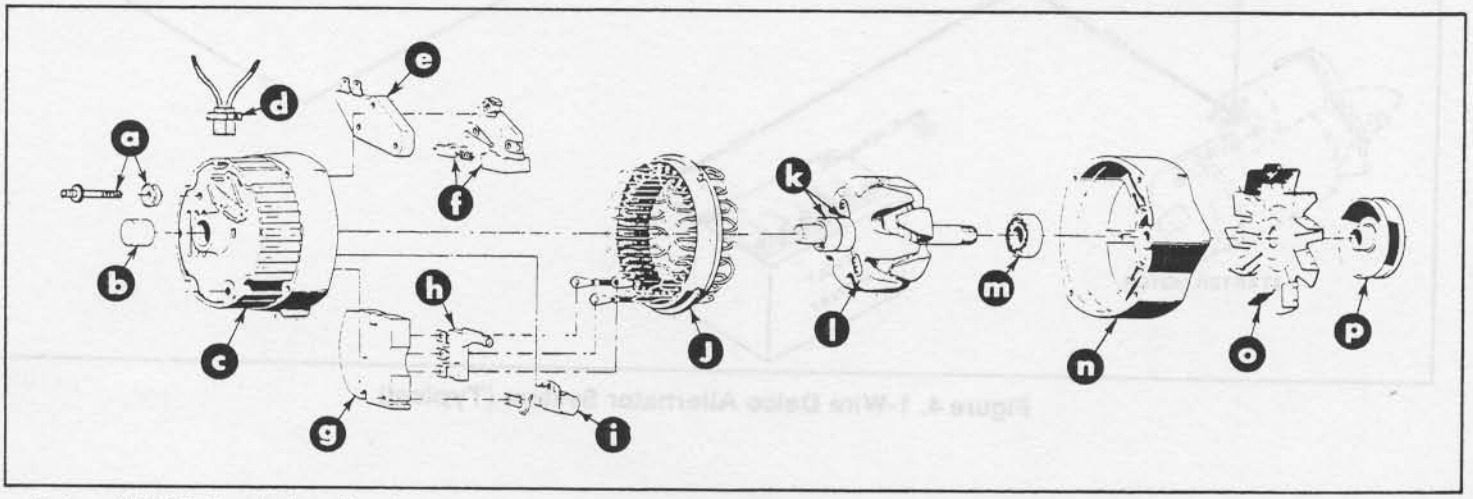


Figure 2. Delco 3-Wire Alternator



a - Battery ("BAT") Terminal and Insulator
b - Slip Ring End Frame Bearing
c - Slip Ring End Frame
d - Regulator Terminal Connector (3-Wire Alternator Only)
e - Voltage Regulator
f - Brushes and Holder Assembly
g - Rectifier Bridge
h - Diode Trio
i - Capacitor
j - Stator
k - Slip Rings
l - Rotor
m - Drive End Frame Bearing
n - Drive End Frame
o - Fan
p - Pulley

Figure 3. Basic Delco Alternator Components

Voltage output of the alternator is maintained within prescribed limits for properly charging the battery by a transistorized voltage regulator that controls the flow of current thru the rotor field circuit. The regulator, which is used on the 1-wire alternator, senses internally within the alternator, while the regulator, that is used on the 3-wire alternator, is equipped with an external sensing circuit that senses near the battery. This external sensing feature allows the alternator to compensate for any resistance in the output circuit, thereby providing more accurate regulation of the voltage being applied to the battery. The voltage regulator, that is used on the 3-wire alternator, also is equipped with an excitation circuit which is connected to the ignition switch. It provides a small amount of current to the rotor field winding to initiate alternator output when starting. This enables the 3-wire alternator to build up voltage faster than the 1-wire alternator which relies solely on residual magnetism for initial start-up. Once the alternator is producing output, current for the rotor field winding is supplied solely by the diode trio. A diode (located in the regulator terminal connector) prevents current from the diode trio from feeding back thru the excitation circuit and into the ignition system, thus preventing engine run-on after the ignition switch is turned off.

Both alternators also are equipped with a fan (mounted on the rotor shaft) which induces air flow thru the alternator to remove the heat created by the rectifier bridge and stator. A capacitor is also utilized to protect the rectifier from high voltages and to suppress radio noise.

Current output of the alternator does not require regulation (as does the DC generator), as maximum current output is self-limited by the design of the alternator. As long as the voltage is regulated within prescribed limits, the alternator cannot produce excessive current. A cutout relay in the alternator system also is not required as the rectifier diodes prevent the battery from discharging back through the stator.

The alternator system, that is used with the 1-wire and 3-wire alternators, is shown in Figures 4 and 5. Both systems include the alternator, ammeter, battery and the wiring which connects these components. The 3-wire alternator system, in addition to these components, also includes the ignition switch and related wiring.

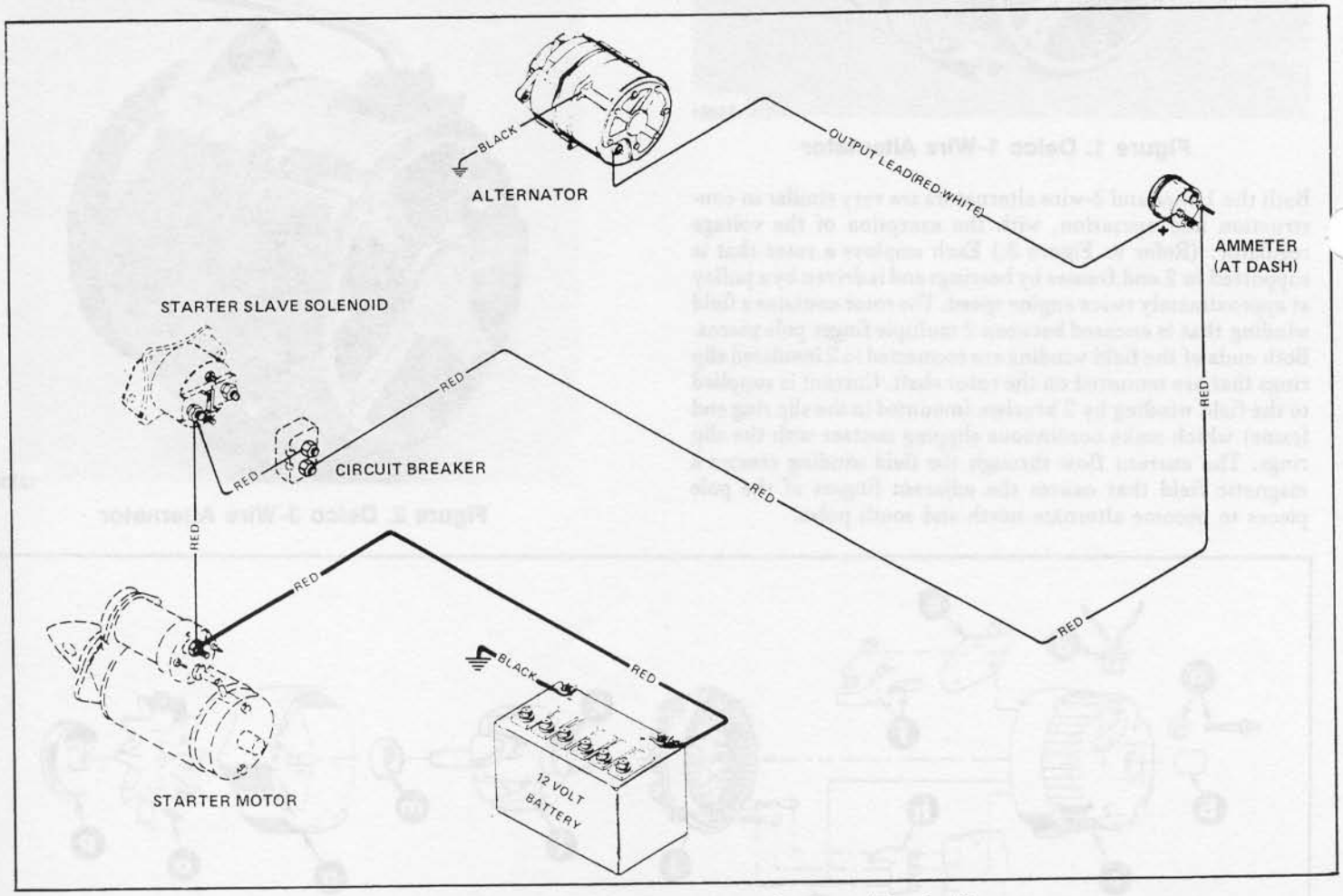


Figure 4. 1-Wire Delco Alternator System (Typical)

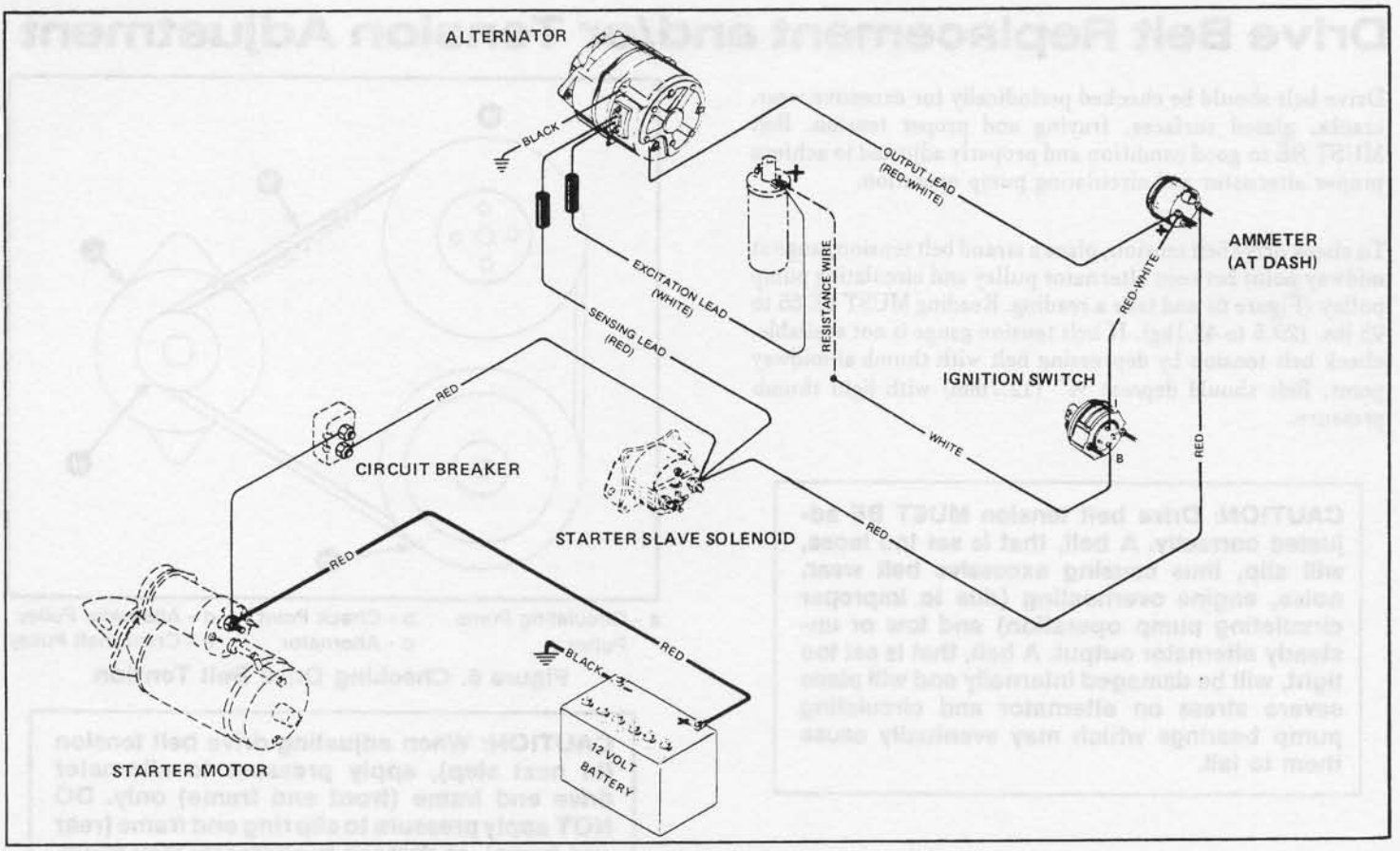


Figure 5. 3-Wire Delco Alternator System (Typical)

Precautions

The following precautions MUST BE observed when working on the alternator system. Failure to observe these precautions may result in serious bodily injury and/or damage to the alternator or alternator system.

1. DO NOT attempt to polarize the alternator.
2. DO NOT short across or ground any of the terminals on the alternator, except as specifically instructed in "Troubleshooting Tests".
3. NEVER disconnect the alternator output lead or battery cables when the alternator is producing a charge. Make sure that all connections in the system are tight before starting the engine.
4. Before disconnecting battery cables (or other leads in alternator system), be sure that engine compartment is well ventilated and that there are no gasoline vapors present to prevent the possibility of an explosion and/or a fire should a spark occur. If boat is equipped with a bilge blower, run blower for at least 5 minutes before disconnecting cables.
5. Always disconnect both battery cables from battery before disconnecting any leads from alternator or other components in alternator system.
6. When installing battery, BE SURE to connect the negative (-) (grounded) battery cable to negative (-) battery terminal and the positive (+) battery cable to positive (+) battery terminal. If cables are reversed, damage to voltage regulator and/or alternator diodes will result.
7. If a charger or booster battery is to be used, BE SURE to connect it in parallel with existing battery (positive to positive, negative to negative).
8. When applying a booster charge to battery, be sure to disconnect both battery cables from battery to prevent alternator diodes and transistorized voltage regulator from being damaged.

Periodic Maintenance

The following maintenance check should be performed every 50 hours or 60 days (whichever comes first) in fresh water areas or every 25 hours or 30 days in salt water areas.

CAUTION: Remove all battery cables from battery (before conducting the following check) to prevent accidentally shorting out electrical system.

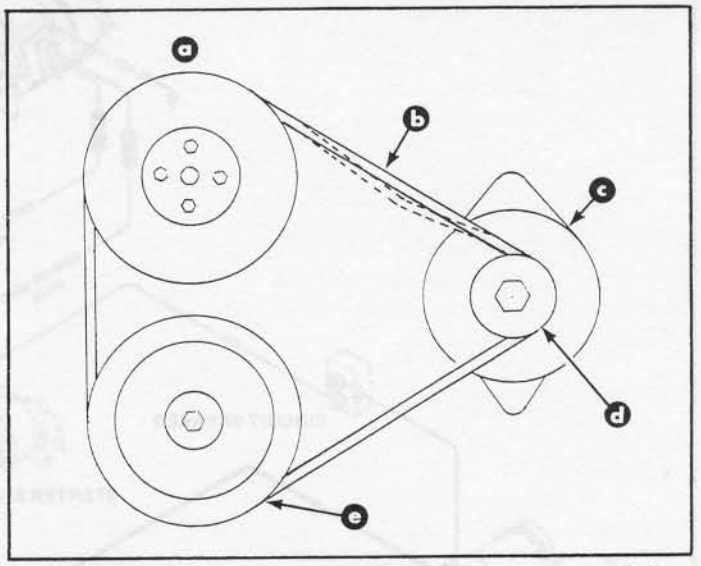
1. Inspect entire alternator system for corroded or loose connections.
2. Check wiring for frayed or worn insulation.
3. Check alternator drive belt for excessive wear, cracks, fraying and glazed surfaces. Also, check drive belt tension and adjust, if necessary, as explained under "Drive Belt Replacement and Tension Adjustment" (see "Index").
4. Check alternator mounting bolts for adequate tightness.
5. Inspect slip ring end frame flame arrestor screen for debris and clean, if necessary, using compressed air or a cloth. Screen MUST BE clean, or alternator may overheat.

Drive Belt Replacement and/or Tension Adjustment

Drive belt should be checked periodically for excessive wear, cracks, glazed surfaces, fraying and proper tension. Belt MUST BE in good condition and properly adjusted to achieve proper alternator and circulating pump operation.

To check drive belt tension, place a strand belt tension gauge at midway point between alternator pulley and circulating pump pulley (Figure 6) and take a reading. Reading MUST BE 65 to 95 lbs. (29.5 to 43.1kg). If belt tension gauge is not available, check belt tension by depressing belt with thumb at midway point. Belt should depress ½" (12.7mm) with light thumb pressure.

CAUTION: Drive belt tension MUST BE adjusted correctly. A belt, that is set too loose, will slip, thus causing excessive belt wear, noise, engine overheating (due to improper circulating pump operation) and low or unsteady alternator output. A belt, that is set too tight, will be damaged internally and will place severe stress on alternator and circulating pump bearings which may eventually cause them to fail.



a - Circulating Pump Pulley
b - Check Point
c - Alternator
d - Alternator Pulley
e - Crankshaft Pulley

Figure 6. Checking Drive Belt Tension

If drive belt replacement or tension adjustment is required, proceed as follows:

1. Loosen alternator brace attaching bolts and alternator mounting bolt.
2. If belt requires replacement, remove water pickup pump belt and Power Steering pump belt, if so equipped, as explained in Section 7 (see "Index"), then pivot alternator inward and replace belt.

CAUTION: When adjusting drive belt tension (in next step), apply pressure to alternator drive end frame (front end frame) only. DO NOT apply pressure to slip ring end frame (rear end frame), as damage to alternator may result.

3. Pivot alternator outward, as required, to obtain correct belt tension, now tighten alternator brace attaching bolts and alternator mounting bolt securely. Set new belt at high reading.
4. Recheck belt tension after tightening bolts.
5. If removed, reinstall water pickup pump belt and Power Steering pump belt, as explained in Section 7.

Troubleshooting Tests (Alternator on Engine)

Use the following tests in conjunction with the troubleshooting procedure under "Alternator System Malfunctioning" in Section 12 (see "Index"). Before proceeding with the tests, however, perform the following checks to eliminate possible problem areas. Also observe "Precautions", immediately preceding, to prevent damage to alternator system.

1. If problem is an undercharged battery, check to ensure that undercharged condition has not been caused by excessive accessory current draw or by accessories which have accidentally been left on. Also, check that undercharged condition has not been caused by running engine at too low a speed for extended periods of time.
2. Check physical condition and state of charge of battery, as outlined under "Storage Batteries" in Section 3-a (see "Index"). Battery MUST BE in good condition to obtain valid results in the following tests.
3. Check battery cable connections and all other accessible alternator system electrical connections for looseness or corrosion.
4. Check alternator drive belt for excessive wear, cracks, fraying and glazed surfaces and replace if necessary. Also, check drive belt tension and adjust, if necessary, as outlined under "Drive Belt Replacement and Tension Adjustment", preceding.

VOLTAGE REGULATION TEST

Perform this test to determine if alternator voltage output is being maintained within prescribed limits for properly charging the battery.

1. Connect positive (+) lead of a DC voltmeter (set on 0-20 volt scale) to positive (+) battery terminal and negative (-) lead to negative (-) terminal. (Figure 7)

IMPORTANT: Battery MUST BE fully charged (1.260 specific gravity or above) to obtain proper voltage reading in next step. If necessary, charge battery with a battery charger or allow engine to run a sufficient length of time to fully charge battery before taking reading. All accessories MUST BE turned off during this test.

2. Start engine and run at fast idle until engine reaches normal operating temperature. Adjust engine speed to

1500-2000 RPM and observe voltmeter for highest reading. Reading should be between 13.9 and 14.7.

NOTE: On 3-wire alternator system only: If reading is normal, but frequent replacement of light bulbs at dash is necessary (indicating high voltage in alternator system), test alternator output circuit for excessive resistance, as explained under "Alternator System Circuitry Test", following.

3. If reading is low, stop engine and perform "Alternator Current Output Test", following, to locate source of problem.
4. If reading is high, stop engine and proceed as follows:
   a. On 3-wire alternator system only: Test alternator system sensing circuit, as explained under "Alternator System Circuitry Test", following.
   b. Remove alternator, disassemble and test the following components, as explained under "Alternator Repair". (See "Index".)
      1) Test upper brush lead clip and voltage regulator for a grounded condition. If grounded, check for a missing or damaged insulator on upper brush lead clip insulated screw. If insulator is good, replace voltage regulator.
      2) Test rotor for a shorted field winding. If shorted, replace both rotor and regulator.
   c. If cause for overcharging condition cannot be found, replace voltage regulator.
   d. Reassemble alternator and reinstall as outlined under "Alternator Repair".

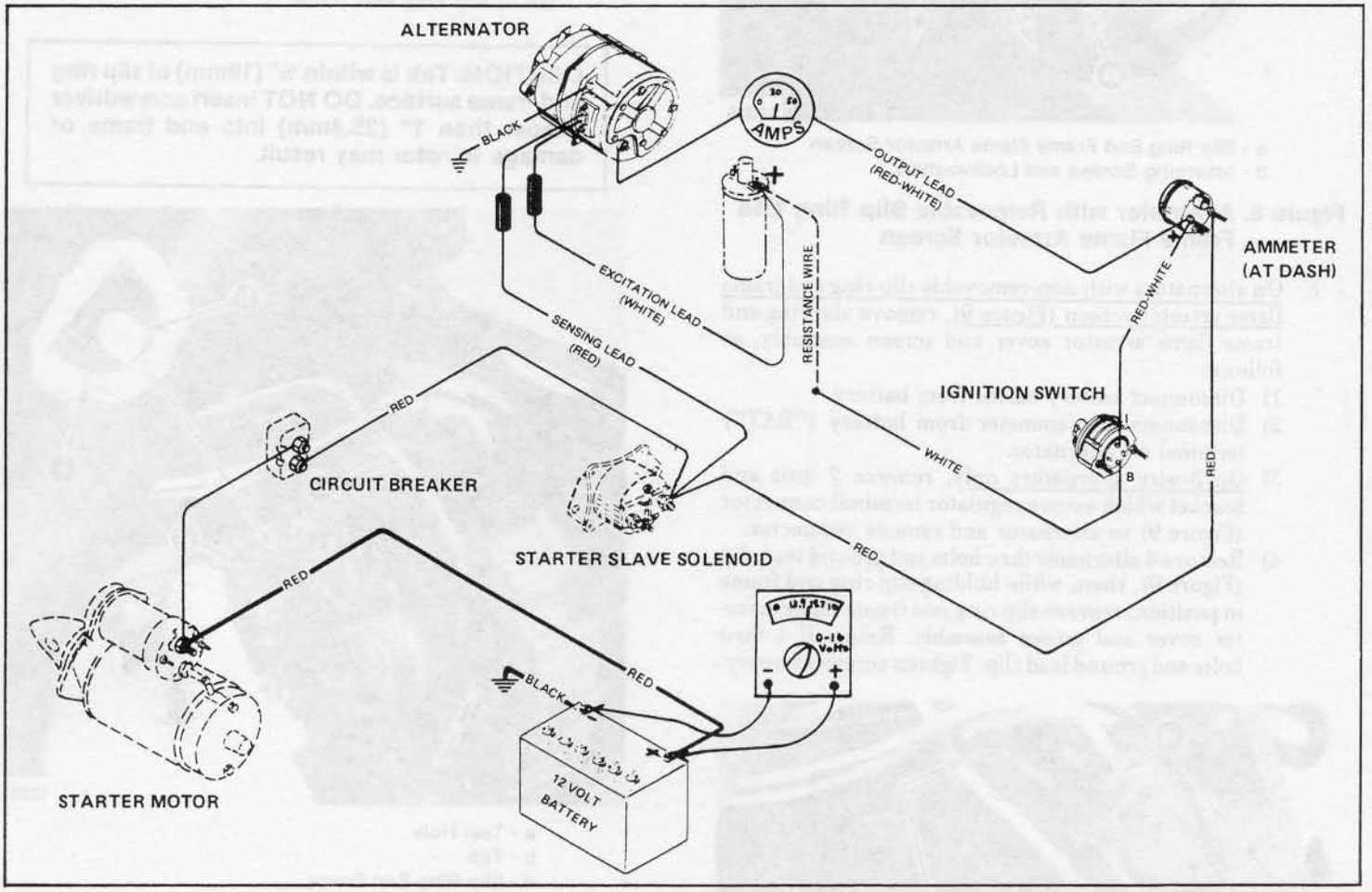
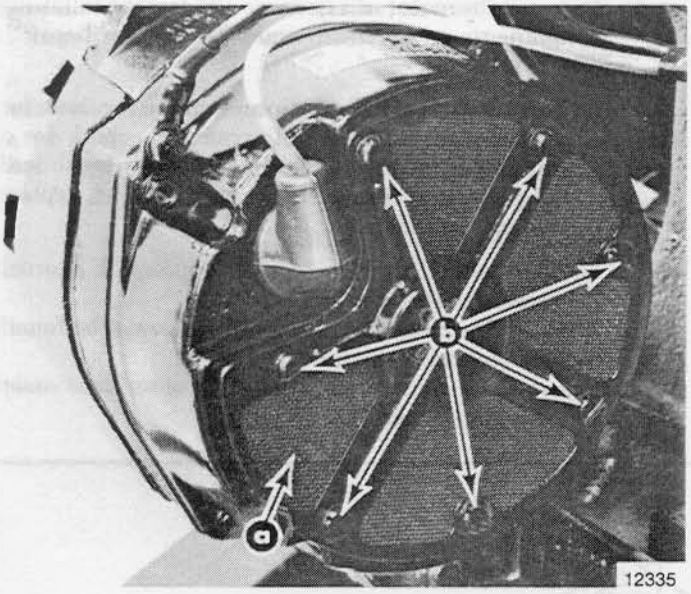


Figure 7. Alternator Voltage Regulator Test and Current Output Test

ALTERNATOR CURRENT OUTPUT TEST

Perform this test to determine if alternator is capable of producing rated current output.

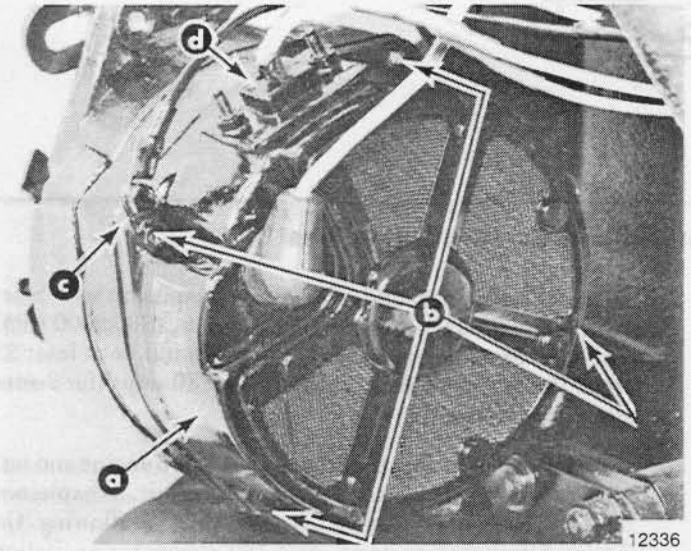
1. Disconnect battery cables from battery.
2. Disconnect red-white engine wiring harness lead from alternator battery ("BAT") terminal and connect a DC ammeter (with 0-50 amp scale) in series between lead and battery terminal. (Figure 7) Connect positive (+) side of ammeter toward battery terminal.
3. Reconnect battery cables.
4. Remove coil hi-tension lead from distributor cap tower and ground it to block. Turn on all accessories and crank engine over with starter motor for 15-20 seconds.
5. Turn off accessories and reinstall coil hi-tension lead. Start engine and quickly adjust engine speed to 1500-2000 RPM and note ammeter reading. Reading should be at least 25 amps (for 1-wire alternator systems) or 30 amps (for 3-wire alternator systems).
6. If no output or low output is indicated, stop engine and test alternator output circuit and ground circuit, as explained under "Alternator System Circuitry Test", following. On 3-wire alternator systems, also test alternator excitation circuit. If circuits test out good, proceed as follows:
   a. On alternators with a removable slip ring end frame flame arrestor screen (Figure 8), remove 7 attaching screws and lockwashers and remove screen.



a - Slip Ring End Frame Flame Arrestor Screen
b - Attaching Screws and Lockwashers

Figure 8. Alternator with Removable Slip Ring End Frame Flame Arrestor Screen

b. On alternators with non-removable slip ring end frame flame arrestor screen (Figure 9), remove slip ring end frame flame arrestor cover and screen assembly, as follows:
   1) Disconnect battery cables from battery.
   2) Disconnect test ammeter from battery ("BAT") terminal on alternator.
   3) On 3-wire alternators only, remove 2 nuts and bracket which secure regulator terminal connector (Figure 9) to alternator and remove connector.
   4) Remove 4 alternator thru bolts and ground lead clip (Figure 9), then, while holding slip ring end frame in position, remove slip ring end frame flame arrestor cover and screen assembly. Reinstall 4 thru bolts and ground lead clip. Tighten screws securely.



a - Slip Ring End Frame Flame Arrestor Cover and Screen Assembly
b - Thru Bolts (One Hidden)
c - Ground Lead Clip
d - Regulator Terminal Connector

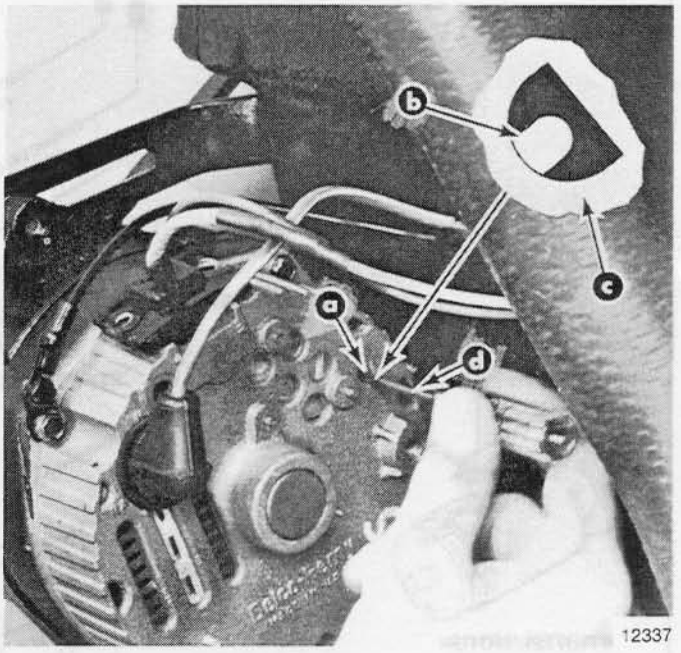
Figure 9. Alternator with Non-Removable Slip Ring End Frame Flame Arrestor Screen

5) Reconnect ammeter, regulator terminal connector and battery cables.

SAFETY WARNING: Be sure that engine compartment is well ventilated and that there are no gasoline vapors present (during the next test) to prevent the possibility of an explosion and/or a fire, should a spark occur. If boat is equipped with a bilge blower, run blower for at least 5 minutes before performing test.

c. Repeat Steps 4 and 5. While observing ammeter, momentarily ground rotor field wind by inserting a screwdriver into test hole (Figure 10) and grounding tab to slip ring end frame.

CAUTION: Tab is within ¾" (19mm) of slip ring end frame surface. DO NOT insert screwdriver deeper than 1" (25.4mm) into end frame, or damage to rotor may result.



a - Test Hole
b - Tab
c - Slip Ring End Frame
d - Ground Tab to End Frame with Screwdriver

Figure 10. Grounding Rotor Field Winding

d. If proper output is now obtained, remove alternator, disassemble and replace voltage regulator, as explained under "Alternator Repair", following.
e. If output is still low, remove alternator, disassemble and test rotor, stator, diode trio and rectifier bridge, as explained under "Alternator Repair", following.
f. Reassemble alternator and reinstall as outlined under "Alternator Repair".

ALTERNATOR SYSTEM CIRCUITRY TEST

Perform the following test to determine if all of the circuits between the alternator and the other components within the system are in good condition.

Output Circuit and Ground Circuit

NOTE: The following test cannot be used on boats equipped with battery isolators.

1. Disconnect battery cables from battery.
2. Disconnect red-white engine wiring harness lead from alternator battery ("BAT") terminal and connect a DC ammeter (with 0-50 amp scale) in series between lead and battery terminal. (Figure 11) Connect positive (+) side of ammeter toward battery terminal.
3. Reconnect battery cables.
4. Connect positive (+) lead of a DC voltmeter (set on 0-20 volt scale) to alternator battery terminal and negative (–) lead to alternator ground terminal. (Test No. 1 in Figure 11)
5. Wiggle engine and instrumentation wiring harness while observing voltmeter. Meter should indicate approximate battery voltage and should not vary. If no reading is obtained, or if reading varies, check alternator output circuit for loose or dirty connections or for damaged wiring. (Refer to appropriate wiring diagram in Section 3, Part E.)
6. Disconnect negative voltmeter lead from alternator ground terminal and reconnect it to positive (+) battery terminal. (Test No. 2 in Figure 11) Set voltmeter on 0-3 volt scale.
7. Start engine and adjust speed to 1500-2000 RPM. Turn on sufficient accessory load to induce a 10 amp charge from alternator (indicated on test ammeter).
8. Note voltmeter reading. Reading should not exceed 1.0 volt. [Reading may be slightly higher on boats with wiring harnesses over 40 ft. (12.2m).] If reading is high, excessive resistance exists in output circuit. If so, stop engine and clean and tighten all output circuit connections.
9. Test ground circuit of alternator for excessive resistance by connecting positive voltmeter lead to negative (–) battery terminal and negative lead to alternator ground terminal. (Test No. 3 in Figure 11) Repeat Step 7 and note voltmeter reading. Reading should not exceed 0.1 volt. If reading is high, STOP ENGINE and clean and tighten all ground circuit connections.
10. Disconnect battery cables, remove meters and reconnect red-white engine wiring harness lead. Then, as a last step, reconnect battery cables.

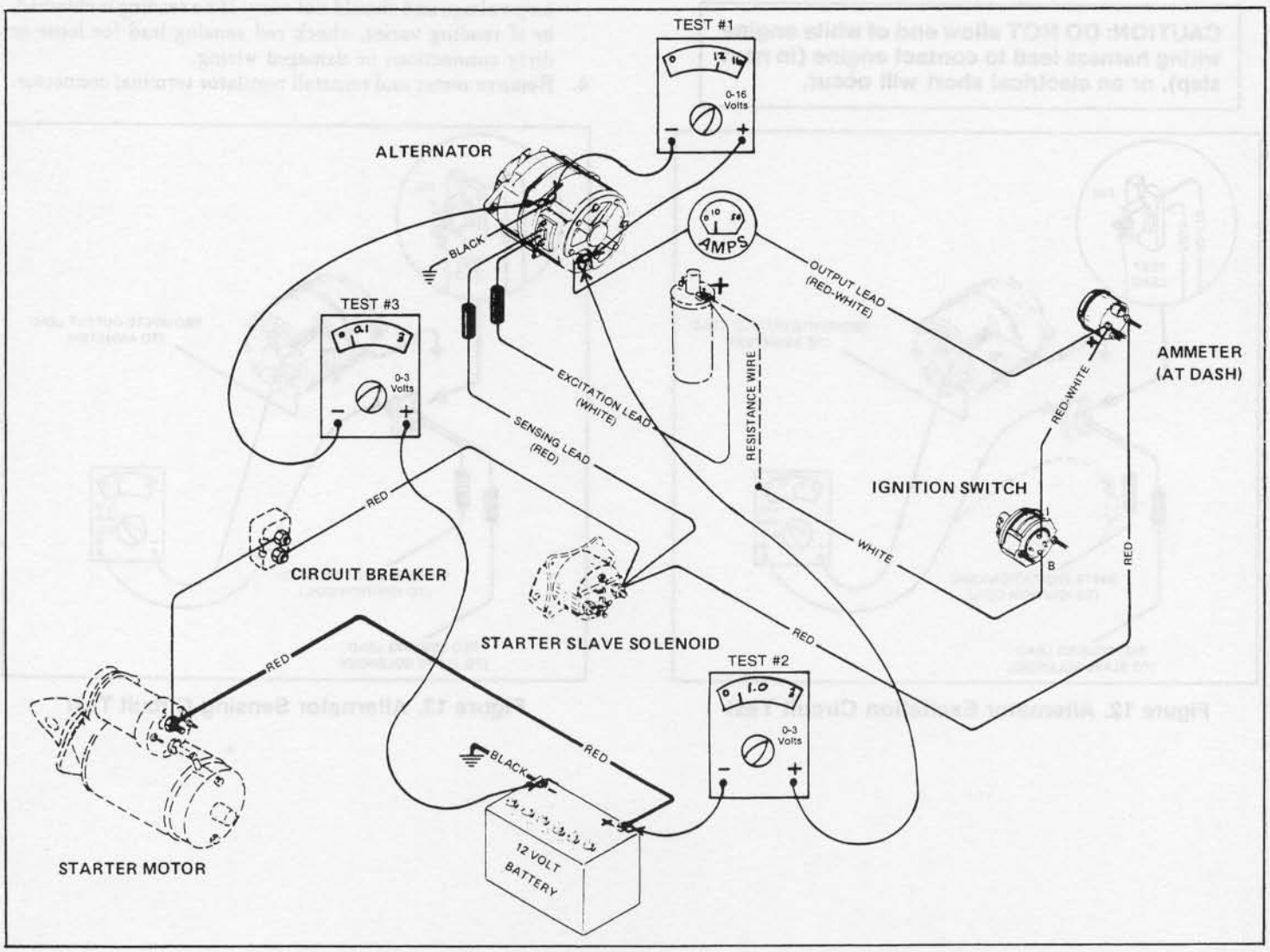


Figure 11. Alternator Output Circuit and Ground Circuit Test

Excitation Circuit (3-Wire Alternator System Only)

1. Remove 2 nuts and bracket, which secure regulator terminal connector (Figure 9) to alternator, and remove connector.
2. Using a pin or similar device, connect positive (+) lead of a DC voltmeter (set on 0-20 volt scale) to terminal in connector to which white wire is attached. Connect negative (-) voltmeter lead to alternator ground terminal. (Figure 12)
3. Turn ignition switch to "On" position.
4. Wiggle portion of engine wiring harness, that contains white excitation lead, while observing voltmeter. Meter should indicate at least 5 volts and should not vary.
5. If no reading is obtained, or if reading varies, turn ignition switch to "Off" and disconnect white engine wiring harness lead from regulator terminal connector at bullet connector.
6. Disconnect positive (+) voltmeter lead from regulator terminal connector and reconnect to white engine wiring harness lead (excitation lead). (Figure 12)

CAUTION: DO NOT allow end of white engine wiring harness lead to contact engine (in next step), or an electrical short will occur.

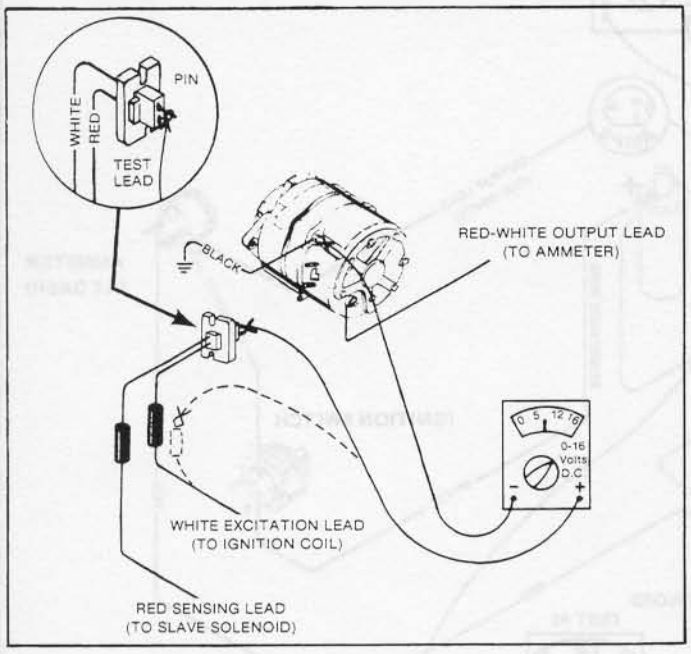


Figure 12. Alternator Excitation Circuit Test

7. Repeat Steps 3 and 4. If proper reading is now obtained, replace regulator terminal connector. If no reading is obtained, or if reading varies, check white engine wiring harness lead for loose or dirty connections or damaged wiring.
8. Reinstall regulator terminal connector. Be sure to insulate bullet connection(s) with heat shrink tubing or at least 4 layers of electrical tape.

Sensing Circuit (3-Wire Alternator System Only)

1. Remove 2 nuts and bracket, which secure regulator terminal connector (Figure 9) to alternator, and remove connector.
2. Using a pin or similar device, connect positive (+) lead of a DC voltmeter (set on 0-20 volt scale) to terminal in connector to which red lead is attached. Connect negative voltmeter lead to alternator ground terminal. (Figure 13)
3. With ignition switch in the "Off" position, wiggle portion of engine wiring harness, that contains red sensing lead, while observing voltmeter. Voltmeter should indicate battery voltage and should not vary. If no reading is obtained, or if reading varies, check red sensing lead for loose or dirty connections or damaged wiring.
4. Remove meter and reinstall regulator terminal connector.

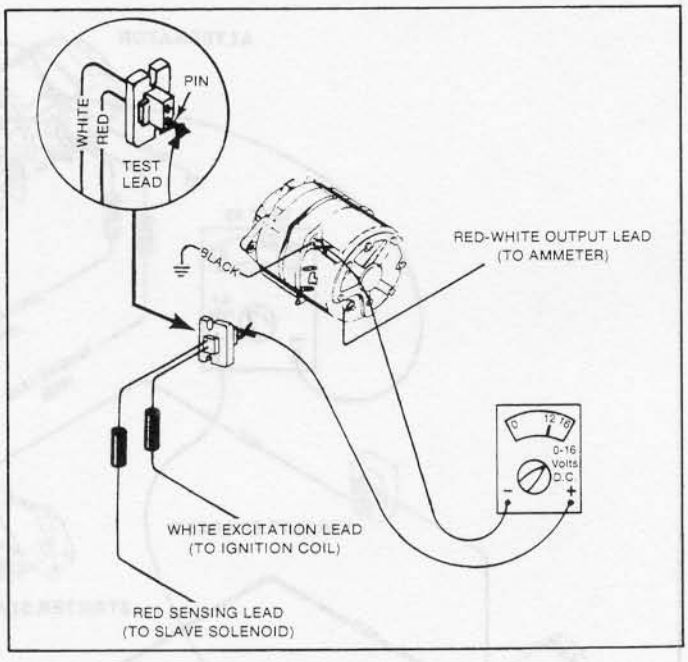
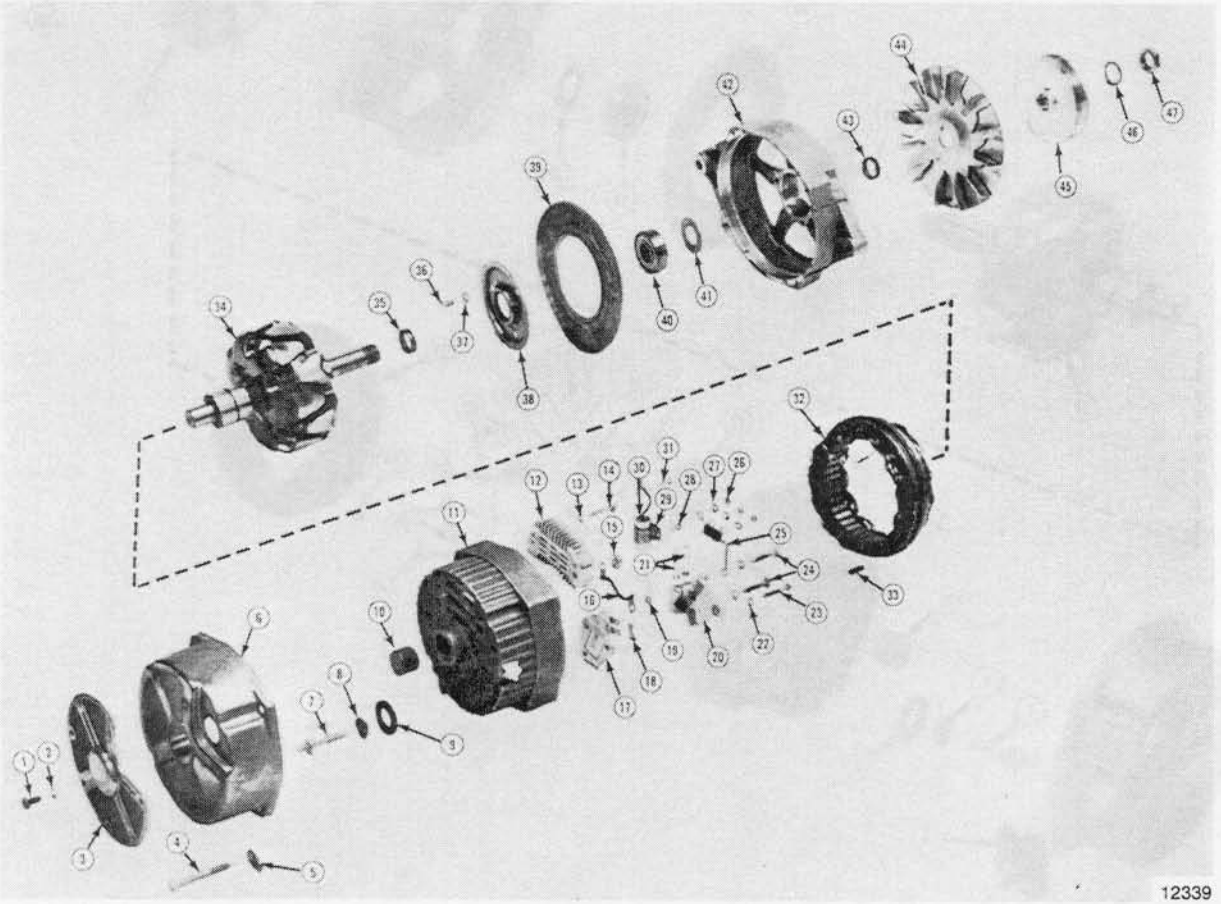


Figure 13. Alternator Sensing Circuit Test

REMOVAL

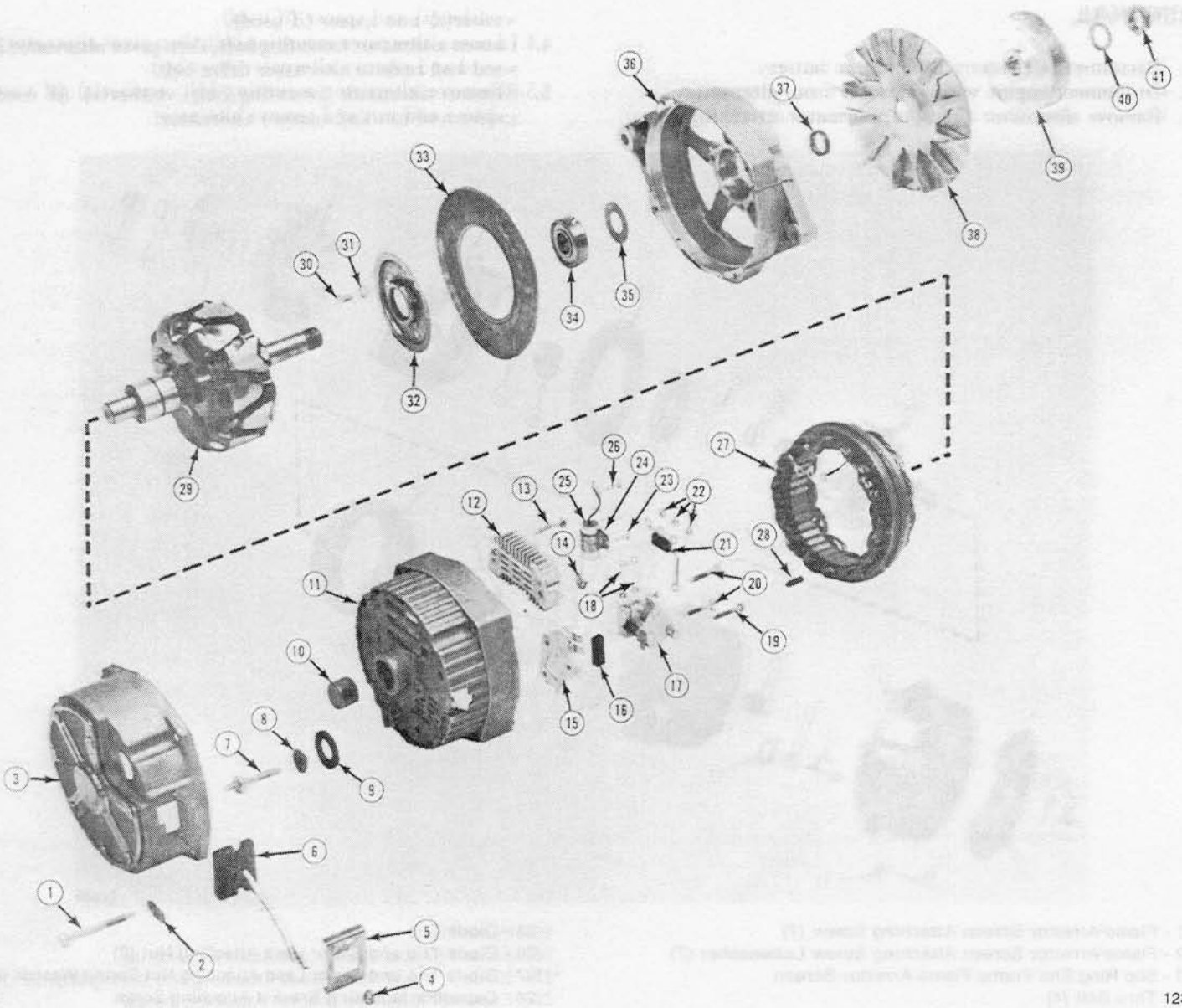
1. Disconnect all battery cables from battery.
2. Disconnect engine wiring harness from alternator.
3. Remove alternator brace to alternator attaching screw, washer(s) and spacer (if used).
4. Loosen alternator mounting bolt, then pivot alternator inward and remove alternator drive belt.
5. Remove alternator mounting bolt, washer(s) (if used), spacer and nut and remove alternator.



§1 - Flame Arrestor Screen Attaching Screw (7)
2 - Flame Arrestor Screen Attaching Screw Lockwasher (7)
§3 - Slip Ring End Frame Flame Arrestor Screen
4 - Thru Bolt (4)
5 - Ground Lead Clip
§6 - Slip Ring End Frame Flame Arrestor Cover
7 - Battery ("BAT") Terminal Screw
8 - Battery Terminal Screw Insulator
§9 - Sponge Rubber Washer
10 - Slip Ring End Frame Bearing
11 - Slip Ring End Frame
12 - Rectifier Bridge
*13 - Rectifier Bridge Attaching Screw Spring Washer
14 - Rectifier Bridge Attaching Screw and Lockwasher Assembly
15 - Rectifier Bridge Attaching Nut
*16 - Rectifier Bridge to Regulator Jumper Wire
17 - Voltage Regulator
18 - Regulator Terminal Shorting Clip
*19 - Jumper Wire to Regulator Attaching Nut
20 - Brush Holder Assembly
21 - Brush Springs
*22 - Brush Holder Assembly and Regulator Attaching Screw Spring Washer (3)
23 - Brush Holder Assembly and Regulator Attaching Screw (Ground)
24 - Brush Holder Assembly and Regulator Attaching Screws (Insulated)
25 - Diode Trio
26 - Diode Trio and Stator Lead Attaching Nut (3)
*27 - Diode Trio and Stator Lead Attaching Nut Spring Washer (3)
28 - Capacitor Mounting Bracket Attaching Screw
29 - Capacitor Mounting Bracket
30 - Capacitor
31 - Capacitor Lead Attaching Screw
32 - Stator
§33 - Stator Frame Rubber Plug
34 - Rotor
*35 - Rotor Shaft Inner Collar [11/32" (8.7mm) Thick]
§36 - Bearing Retainer Plate Attaching Screw and Lockwasher Assembly (3)
*37 - Bearing Retainer Plate Attaching Screw Spring Washer (3)
§38 - Bearing Retainer Plate
§39 - Drive End Frame Flame Arrestor Screen
40 - Drive End Frame Bearing
41 - Grease Slinger Washer
42 - Drive End Frame
43 - Rotor Shaft Outer Collar [7/32" (5.6mm) Thick]
44 - Fan
45 - Pulley
46 - Pulley Attaching Nut Lockwasher
47 - Pulley Attaching Nut

* *May not be used on some alternators.*
§ *Part(s) must be installed for alternator to be properly flame arrested.*

Figure 14. 1-Wire Alternators B-59755 (Delco Remy No. 1100576), B-59756 (1100577), B-68085 (1102393) and B-69729 (1102496) - Exploded Parts View



1 - Thru Bolt (4)
2 - Ground Lead Clip
§3 - Slip Ring End Frame Flame Arrestor Cover
4 - Regulator Terminal Connector Attaching Nut (2)
5 - Regulator Terminal Connector Attaching Bracket
6 - Regulator Terminal Connector
7 - Battery ("BAT") Terminal Screw
8 - Battery Terminal Screw Insulator
§9 - Sponge Rubber Washer
10 - Slip Ring End Frame Bearing
11 - Slip Ring End Frame
12 - Rectifier Bridge
13 - Rectifier Bridge Attaching Screw and Washer Assembly
14 - Rectifier Bridge Attaching Nut
15 - Voltage Regulator
§16 - Regulator Terminal Sponge Rubber Boot
17 - Brush Holder Assembly
18 - Brush Springs
19 - Brush Holder and Regulator Attaching Screw (Ground)
20 - Brush Holder and Regulator Attaching Screws (Insulated)
21 - Diode Trio
22 - Diode Trio and Stator Lead Attaching Nuts (3)
23 - Capacitor Mounting Bracket Attaching Screw
24 - Capacitor Mounting Bracket
25 - Capacitor
26 - Capacitor Lead Attaching Screw
27 - Stator
§28 - Stator Frame Rubber Plug
29 - Rotor
§30 - Bearing Retainer Plate Attaching Screw and Lockwasher Assembly (3)
*31 - Bearing Retainer Plate Attaching Screw Spring Washer (3)
§32 - Bearing Retainer Plate
§33 - Drive End Frame Flame Arrestor Screen
34 - Drive End Frame Bearing
35 - Grease Slinger Washer
36 - Drive End Frame
37 - Rotor Shaft Collar
38 - Fan
39 - Pulley
40 - Pulley Attaching Nut Lockwasher
41 - Pulley Attaching Nut

* *May not be used on some alternators.*
§ *Part(s) must be installed for alternators to be properly flame arrested.*

Figure 15. 3-Wire Alternator B-78477 (Delco Remy No. 1102938 or 1102939) - Exploded Parts View

NOTE: The following instructions are for complete disassembly and overhaul of alternator. In many cases, however, complete alternator disassembly is not required and, in those cases, it is necessary to perform only the operations which are required to repair or replace the faulty part.

DISASSEMBLY (Refer to Figure 14 or 15)

1. Mount alternator in a vise by clamping on mounting flange.
2. Scribe a mark on slip ring end frame and drive end frame to ensure proper reassembly later.
3. Remove 4 alternator thru bolts and ground lead clip and separate slip ring end frame and stator assembly from drive end frame and rotor assembly, being careful not to lose brush springs. If necessary, insert a screwdriver between stator and drive end frame and pry assemblies apart. DO NOT insert screwdriver so far that it contacts stator windings.

IMPORTANT: Brushes may drop onto rotor shaft and become contaminated with bearing lubricant. Be sure to clean brushes prior to installing with a non-toxic cleaner (such as trichlorethylene) and a soft dry cloth. If lubricant is not removed, brushes will not make good contact with slip rings, resulting in poor alternator performance.

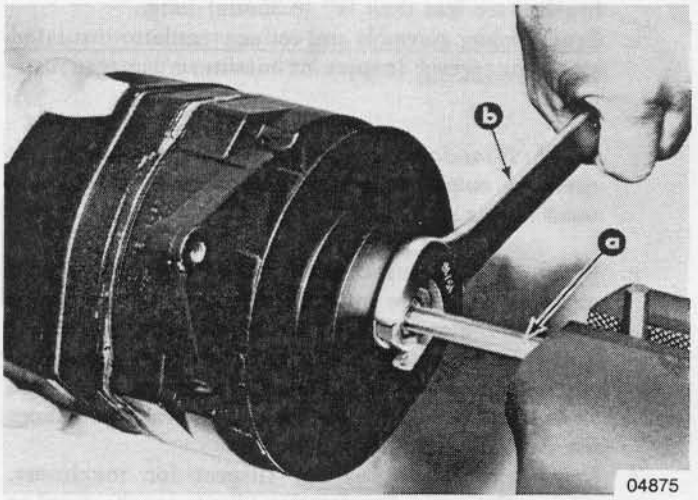
4. Place a piece of tape over bearing surface on rotor shaft to protect it from getting nicked or scratched. If slip ring end frame bearing is not to be replaced, also place a piece of tape over bearing opening to prevent dirt or other foreign material from entering.
5. On 3-wire alternator only, remove 2 nuts and bracket, which secure regulator terminal connector to slip ring end frame, and remove connector.
6. Remove flame arrestor cover from slip ring end frame.

NOTE: If troubleshooting an overcharging condition, rotor can be tested for a short, and upper brush lead and regulator can be tested for grounds with alternator disassembled to this point. Refer to "Component Testing", following.

7. Remove diode trio and stator lead attaching nuts (and spring washers, if so equipped) and separate stator from slip ring end frame. Remove rubber plug from groove on outside edge of stator frame.
8. Remove insulated screw (and spring washer, if so equipped), which attach diode trio to brush holder assembly, and remove diode trio.
9. Remove capacitor mounting bracket attaching screw and capacitor lead attaching screw and remove capacitor.

NOTE: With alternator disassembled to this point, stator, rotor, rectifier bridge, diode trio, regulator terminal connector and capacitor can be tested, as explained under "Component Testing", following.

10. Remove screw, washer and nut, which secure rectifier bridge to slip ring end frame, and remove rectifier bridge. Also remove battery terminal screw, insulating washer and sponge rubber washer from end frame.
11. Remove remaining insulated screw and ground screw (and spring washers, if so equipped), which secure brush holder assembly and voltage regulator to slip ring end frame, and remove brush holder assembly and regulator.
12. On 1-wire alternators so equipped, remove nut that secures jumper wire to voltage regulator and remove wire.
13. If slip ring end frame bearing requires replacement, press bearing out of end frame (from outside inward), using a suitable driver and an arbor press. Bearing MUST BE replaced, if grease supply is exhausted. Make no attempt to re-lubricate old bearing.
14. Remove pulley attaching nut from rotor shaft by turning nut in counterclockwise direction with a 15/16" box end wrench, while holding rotor shaft with a 5/16" allen wrench, as shown in Figure 16.



a - 5/16" Allen Wrench
b - 15/16" Box End Wrench

Figure 16. Removing Pulley Attaching Nut

15. Remove washer, pulley, fan and collar from rotor shaft. Now remove rotor and inner collar (if so equipped) from drive end frame.
16. Remove drive end frame bearing retainer plate attaching screws (and spring washers, if so equipped), then remove retainer plate and flame arrestor screen from end frame.
17. If drive end frame bearing requires replacement, press bearing and grease slinger washer out of end frame, using a suitable driver and an arbor press.

CLEANING and INSPECTION

CAUTION: DO NOT clean electrical components with solvent (in next step), as components may be damaged.

1. Clean all electrical components with a clean, soft cloth ONLY. Clean non-electrical components (except slip ring end frame bearing) with solvent and dry with compressed air.
2. Clean brushes with a non-toxic solvent (such as trichlorethylene) and a soft cloth.

CAUTION: Rotor MUST BE spun while cleaning slip rings (in next step). Cleaning the slip rings by hand, without spinning the rotor, may result in flat spots on the slip rings and cause brush noise and excessive slip ring and brush wear.

3. Clean rotor slip rings with 400 grain (or finer) polishing cloth while spinning rotor in a lathe. Blow off dust with compressed air. If slip rings are rough or out-of-round

[.002" (0.051mm) maximum], true slip rings in a lathe, removing only enough material to make rings smooth and round. Finish with 400 grain or finer polishing cloth. If slip rings are damaged beyond repair, rotor MUST BE replaced.

4. Inspect the following parts for wear and damage -
   a. Brush and holder assembly: Inspect for cracked porcelain casing, damaged brush leads, poor brush lead connections, damaged brush lead clips or worn brushes. Brush holder assembly MUST BE replaced, if brushes are less than ¼" (6.35mm) long.
   b. Brush holder assembly and voltage regulator insulated attaching screws: Inspect for missing or damaged insulators.

      NOTE: If insulator on insulated screws is missing or damaged, no output or uncontrolled alternator output will result during operation.

   c. Brush springs: Inspect for corrosion or distortion and check for adequate spring tension.
   d. Voltage regulator: Inspect for cracked porcelain case.
   e. Rotor: Inspect for damaged threads, scuffed pole piece fingers or damaged bearing surfaces. Rotor MUST BE replaced, if pole pieces are scuffed or bearing surfaces are damaged.
   f. Drive end frame bearing: Inspect for roughness, pitting, flat spots, discoloration (due to overheating) or excessive side or end play. Hold inner race of bearing while turning outer race. Bearing should turn freely without binding or evidence of rough spots.
   g. Drive end frame bearing retainer: Inspect seal for excessive wear, cracks, roughness or other signs of deterioration.
   h. Slip ring end frame bearing: Inspect for flat spots, pitting or discoloration due to overheating. Inspect bearing seal for cracks, flat spots, roughness or other signs of deterioration. Entire bearing MUST BE replaced, if seal is damaged. Also check bearing for adequate lubrication. If grease supply is exhausted, bearing MUST BE replaced. Make no attempt to re-lubricate bearing.
   i. End frames: Inspect for cracks, distortion, stripped threads or wear in bearing bore due to a spun bearing. End frame(s) MUST BE replaced, if bearing(s) have spun.
   j. Stator: Inspect for damaged insulation or wires. Also, inspect insulation for heat discoloration, as this usually is a sign of a shorted or grounded winding.
   k. Fan: Inspect for cracked or bent fins or broken welds on bi-rotational fans.
   l. Pulley: Inspect pulley sheaves for rotational trueness, undercut surfaces (from excessive wear), nicks, pitting or corrosion. Repair surfaces, if possible, with a fine file and a wire brush or replace pulley, if beyond repair. Drive surfaces MUST BE perfectly true and smooth, or drive belt wear will be greatly accelerated.

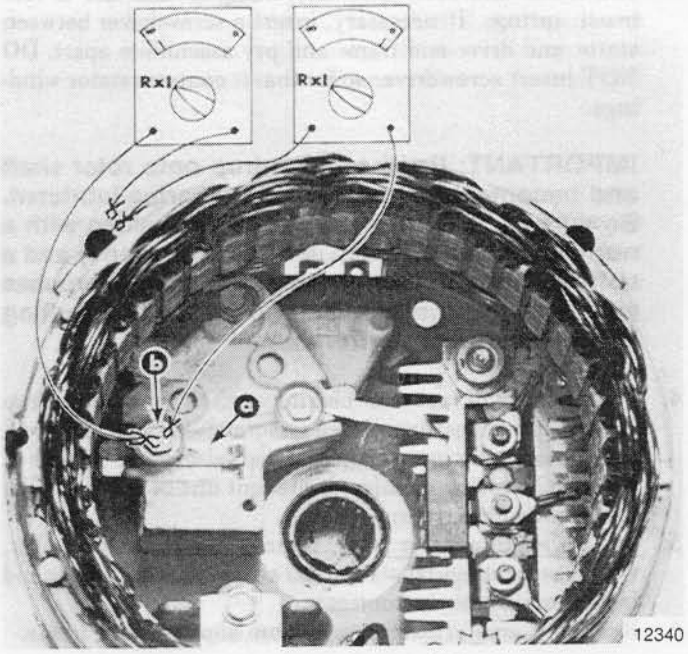
COMPONENT TESTING

Upper Brush Lead Clip and Regulator Ground Test

NOTE: The following test need be performed only if an overcharging condition exists.

1. Connect one lead of an ohmmeter (set on Rx1 scale) to upper brush lead clip and the other lead to slip ring end frame, as shown in Figure 17. Note ohmmeter reading.
2. Reverse ohmmeter leads and again note reading.
3. If both readings are zero, either upper brush lead clip is grounded or voltage regulator is defective. A grounded brush lead clip can result from a damaged or missing insulator on insulated screw that secures upper brush lead clip. Remove screw and inspect insulator. If satisfactory, replace voltage regulator.

NOTE: Some older alternators may have an insulated screw with a separate insulating sleeve and washer instead of a one-piece insulator. On these alternators, be sure that both insulating sleeve and washer are not missing or damaged.



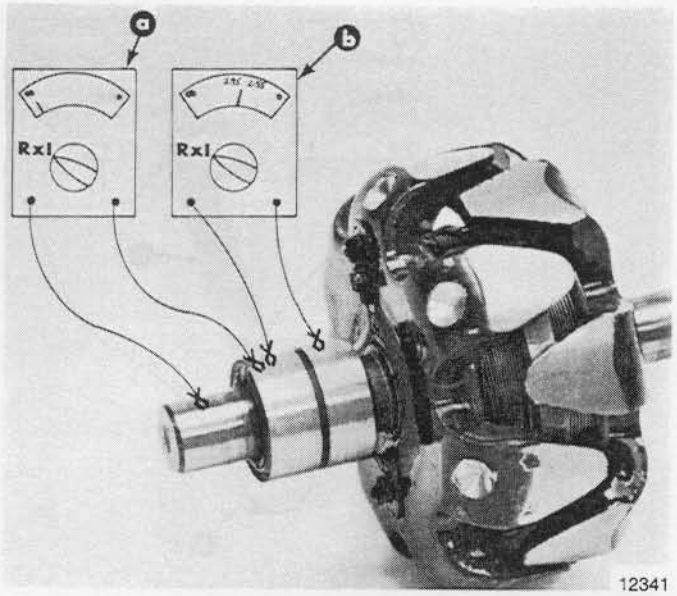
a - Upper Brush Lead Clip
b - Insulated Screw

Figure 17. Testing for Grounded Brush Lead Clip or Defective Regulator

Rotor

1. Test rotor field circuit for grounds, using an ohmmeter (set on Rx1 scale) or a 110-volt AC continuity test lamp, as follows:
   a. Connect one lead of ohmmeter or test lamp to either slip ring and the other lead to rotor shaft. (Figure 18)
   b. Meter or test lamp should indicate no continuity (meter should not move; lamp should not lite).
   c. If continuity exists, rotor field is grounded and rotor must be replaced.
2. Test rotor field for shorts or opens, using an ohmmeter (set on Rx1 scale), as follows:
   a. Connect one ohmmeter lead to each slip ring. (Figure 18)
   b. Ohmmeter reading should be 2.55 to 2.95 ohms with rotor at room temperature [60°-80°F (16°-27°C)].
   c. If reading is low, rotor field is shorted. If reading is high or infinite (no meter movement), high resistance or an open exists in field. In either case, rotor must be replaced.

NOTE: If alternator has output at low speed but no output at high speed, rotor field winding may be shorting or grounding out due to centrifugal force. Replace rotor if this situation exists, and if all other electrical components test good.



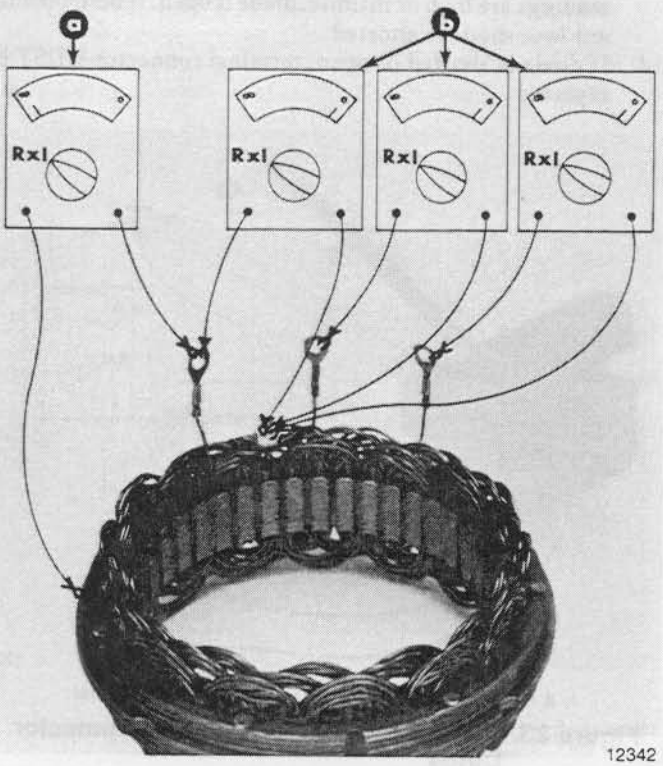
a - Test for Grounds
b - Test for Shorts or Opens

Figure 18. Testing Rotor Field Circuit

Stator

NOTE: Stator leads MUST BE disconnected from rectifier bridge for this test.

1. Test stator for grounds, using an ohmmeter (set on Rx1 scale) or a 110 volt AC continuity test lamp, as follows:
   a. Connect one lead of ohmmeter or test lamp to one of the stator leads and the other lead to stator frame. (Figure 19) Be sure that leads make good contact with stator frame.
   b. Meter or test lamp should indicate no continuity (meter should not move; lamp should not lite). If continuity does exist, stator is grounded and must be replaced.



a - Testing for Grounds
b - Testing for Opens

Figure 19. Testing Stator Windings

2. Test for opens in stator, using an ohmmeter (set on Rx1 scale) or a 110 volt AC continuity test lamp, as follows:
   a. Connect ohmmeter or test lamp between junction clip and each of the stator winding lead terminals (3 different ways). (Figure 19)
   b. Continuity should exist in all 3 cases (meter should move; lamp should lite). If it does not, a winding is open and stator must be replaced.
3. A short in the stator is difficult to detect without special laboratory equipment due to the low resistance of the windings. If all other electrical components test out good, and alternator fails to produce rated output but will produce a minimum of 5 amps output, stator probably is shorted and should be replaced.

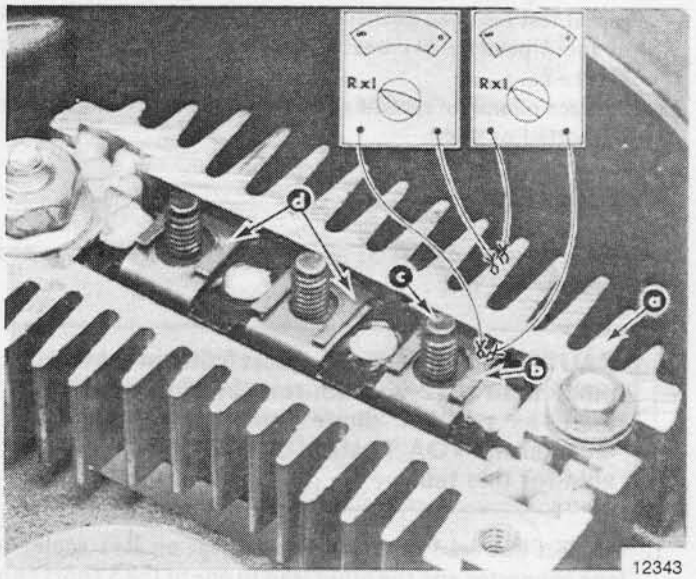
Rectifier Bridge

NOTE: Rectifier bridge can be tested while installed in end frame. Stator and diode trio, however, MUST BE removed.

CAUTION: DO NOT use a test instrument with more than a 12-volt source (in the following test), as rectifier bridge may be damaged. Quicksilver VOA Tester (C-91-62562) is suitable for this test.

1. Connect one lead of an ohmmeter (set on Rx1 scale) to negative (grounded) heat sink and the other lead to one of the negative (-) heat sink diode leads. (Figure 20)

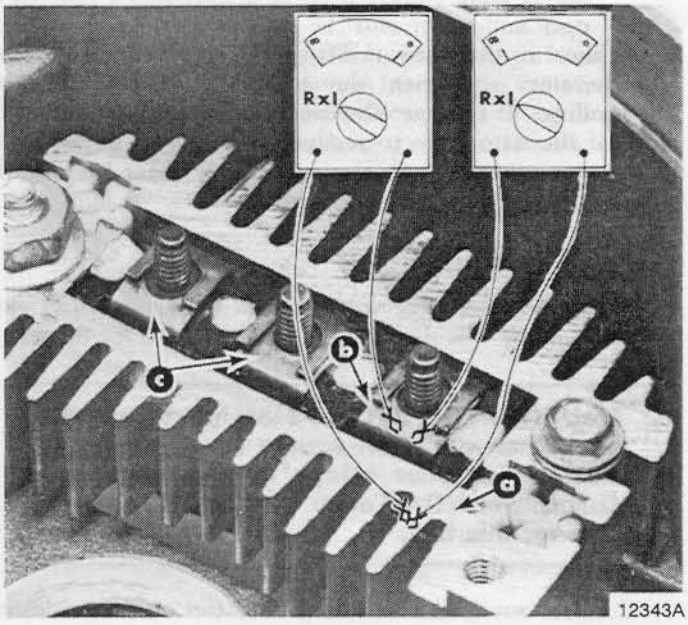
IMPORTANT: DO NOT connect ohmmeter test lead directly to rectifier bridge terminal studs, as diode leads may not be making good contact with studs with terminal nuts removed.



a - Negative (Grounded) Heat Sink
b - Negative (-) Heat Sink Diode Lead
c - DO NOT Connect Test Lead to Stud
d - Repeat Same Test for These 2 Negative Heat Sink Diode Leads

Figure 20. Testing Negative Heat Sink Diodes

2. Reverse test leads and again note reading.
3. Meter should indicate a high or infinite resistance (no meter movement), when connected one way, and a low reading when connected the other. If both readings are high or infinite, diode is open. If both readings are low, diode is shorted.



a - Positive (Insulated) Heat Sink
b - Positive (+) Heat Sink Diode Lead
c - Repeat Test for These 2 Positive Heat Sink Diode Leads

Figure 21. Testing Positive Heat Sink Diodes

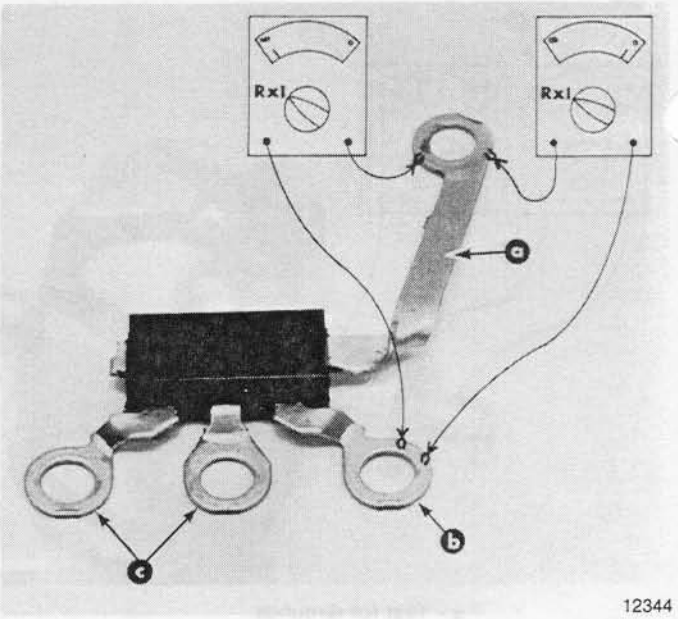
4. Repeat same test between negative (-) heat sink and 2 other negative heat sink diode leads. (Figure 20) Also repeat test between positive (insulated) heat sink and each of the 3 positive (+) heat sink diode leads, as shown in Figure 21.
5. Replace complete rectifier bridge, if any one of the diodes is shorted or open.

Diode Trio

NOTE: Diode trio MUST BE removed from slip ring end frame for this test.

CAUTION: DO NOT use a test instrument with more than a 12-volt source (in the following test), as rectifier diodes may be damaged. Quicksilver VOA Tester (C-91-62562) is suitable for this test.

1. Connect one lead of an ohmmeter (set on Rx1 scale) to long connector and the other lead to one of the 3 short connectors. (Figure 22) Note ohmmeter reading.
2. Reverse ohmmeter leads and again note reading.
3. Meter should indicate a high or infinite reading, when meter is connected one way, and a low reading when meter is connected the other way. If both readings are high or infinite, diode (in diode trio) is open. If both readings are low, diode is shorted.
4. Repeat same test between long connector and other 2 short connectors.
5. Replace diode trio if ANY of the diodes (in diode trio) are shorted or open.

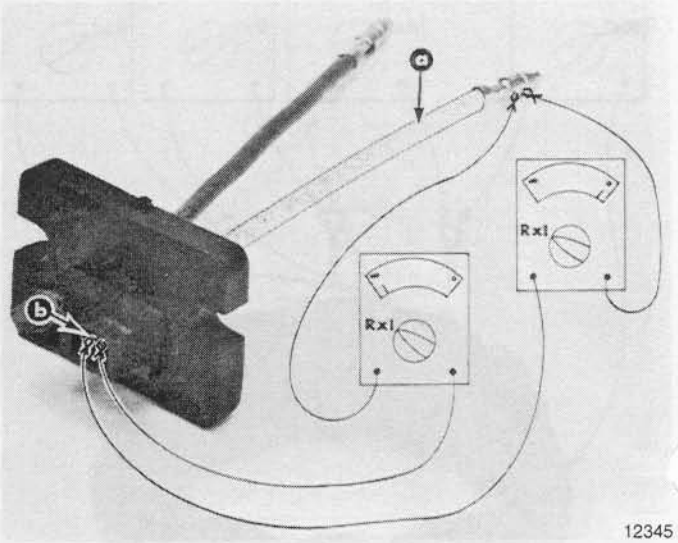


a - Long Connector
b - Short Connector
c - Repeat Test between Long Connector and These 2 Short Connectors

Figure 22. Testing Diode Trio

Regulator Terminal Connector (3-Wire Alternator Only)

1. Check excitation lead diode in regulator terminal connector for shorts or opens by connecting one lead of an ohmmeter (set on Rx1 scale) to white lead bullet connector and other lead to corresponding terminal in connector. (Figure 23) Note ohmmeter reading.
2. Reverse ohmmeter leads and again note reading.
3. Meter should indicate a high or infinite reading (no meter movement), when meter is connected one way, and a low reading when meter is connected the other way. If both readings are high or infinite, diode is open. If both readings are low, diode is shorted.
4. If diode is shorted or open, terminal connector MUST BE replaced.



a - White Lead b - White Lead Terminal

Figure 23. Testing Regulator Terminal Connector Diode

NOTE: If diode in terminal connector is shorted, engine will continue to run after ignition switch has been turned off.

Capacitor

1. Using Magneto Analyzer (C-91-25213 or C-91-31800) and accompanying instructions, perform the following capacitor (condenser) tests:
   a. Capacitor capacity test (must be .5 mfd)
   b. Capacitor short or leakage test
   c. Capacitor series resistance test
2. Replace capacitor, if test results are not within specifications.

ALTERNATOR REASSEMBLY (Refer to Figure 14 or 15)

SAFETY WARNING: All parts, that are marked with the symbol (§) in Figures 14 and 15, MUST BE reinstalled for alternator to be properly flame-arrested.

1. Fill drive end frame bearing one-quarter full with Ball Bearing Lubricant (Delco-Remy Part No. 1948791). DO NOT over-fill, as this may cause bearing to overheat.
2. Place grease slinger washer into recess in drive end frame bearing bore, then press bearing into end frame (with open end upward), using a bearing driver that contacts outer bearing race only.
3. Install flame arrestor screen (if so equipped) in drive end frame, then install retainer plate and secure with 3 screws (and spring washers, if so equipped). Torque screws to 14-18 in. lbs. (16-21kg-cm). Shape edges of flame arrestor screen to fit snugly against inside contour of end frame.

SAFETY WARNING: Flame arrestor screen MUST fit snugly against inside contour of end frame or flame arresting property of screen will be lost.

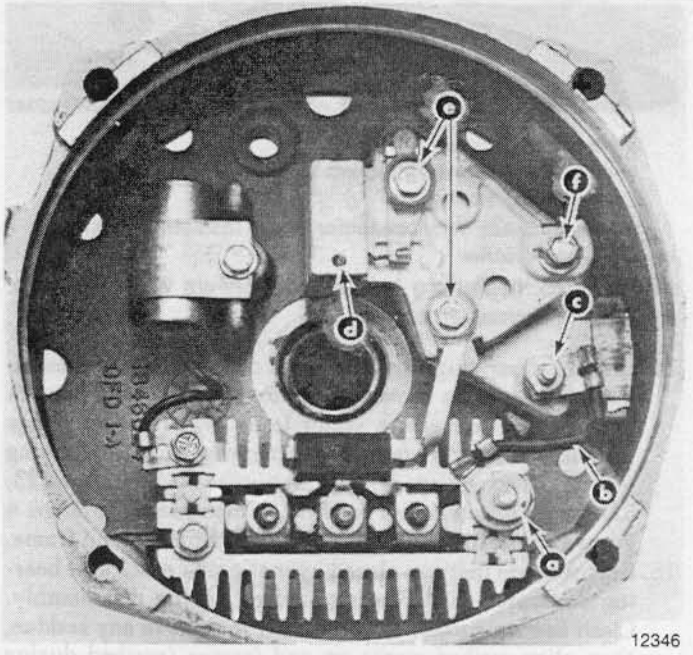
4. If not already done, clean rotor slip rings as explained under "Cleaning and Inspection", preceding.
5. If so equipped, install 11/32" (8.7mm) thick collar on rotor shaft, then install rotor in drive end frame. Place 7/32" (5.6mm) collar, fan, pulley and lockwasher on shaft and secure with nut. Torque nut to 40-50 ft. lbs. (5.5-6.9 mkg) while holding rotor shaft with a 5/16" allen wrench.
6. Press new bearing into slip ring end frame with a flat plate or other suitable tool until bearing is flush with outside surface of end frame. Support inside of end frame around bearing bore with a suitable tool to prevent distortion. Use extreme care to prevent bearing misalignment or otherwise placing undue stress on the bearing.

IMPORTANT: Slip ring end frame bearing MUST BE replaced, if grease supply is exhausted. Make no attempt to re-lubricate bearing. Also, DO NOT lubricate new bearing, as bearing is lubricated at the factory, and additional lubricant will ooze out and get on slip rings when alternator is reassembled.

7. Place rectifier bridge in position in slip ring end frame and secure with battery ("BAT") terminal screw, insulator and nut on one end and screw (and spring washer if so equipped) on the other. On alternators so equipped, also install rectifier bridge to regulator jumper wire under rectifier bridge attaching nut, as shown in Figure 24. Torque attaching nut to 40-50 in. lbs. (46-58kg-cm) and attaching screw to 14-18 in. lbs.
8. Slide condenser into mounting bracket, then install condenser and mounting bracket assembly in slip ring end frame and connect lead to rectifier bridge. Torque capacitor attaching screws to 14-18 in. lbs.
9. Install shorting clip (on 1-wire alternators) or sponge rubber boot (on 3-wire alternator) over voltage regulator terminals and place regulator in position in slip ring end frame.

IMPORTANT: Before installing brushes in brush holder (in next step), clean brushes with a non-toxic cleaner (such as triclorethylene) to remove any residue that may exist. If residue is not removed, brushes may not make good contact with slip rings, which will result in poor alternator performance.

10. Insert brush springs and brushes into brush holder and hold them in place by inserting a toothpick or piece of wire thru holes in brush holder. Place brush holder assembly in position on top of regulator with toothpick or wire protruding thru hole in slip ring end frame. (Figure 24)
11. Place diode trio in position on rectifier bridge terminals and center diode trio connector over attaching hole in brush holder assembly.
12. Secure diode trio connector, brush holder assembly and voltage regulator with 2 insulated screws and ground screw (and 3 spring washers, if so equipped), as shown in Figure 24. Torque screws EVENLY to 20-25 in. lbs. (23-29kg-cm).



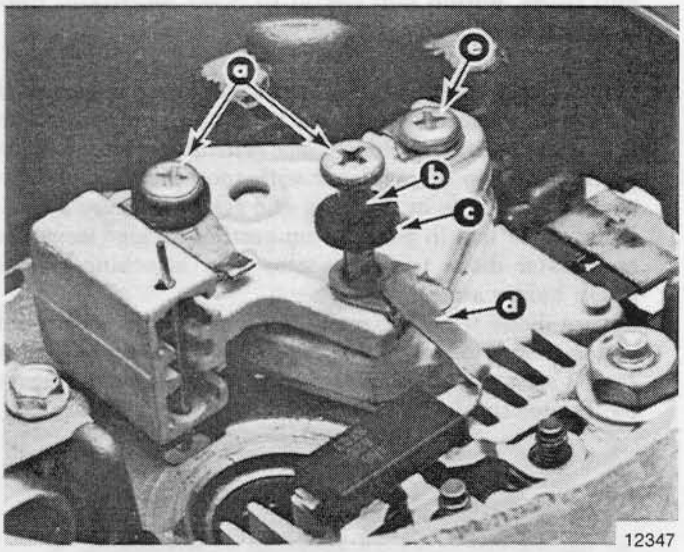
a - Rectifier Bridge Attaching Nut
b - Rectifier Bridge to Regulator Jumper Wire (if so Equipped)
c - Regulator Terminal Nut
d - Toothpick or Wire Retaining Brushes
e - Insulated Screws
f - Ground Screw

Figure 24. Voltage Regulator and Brush Holder Assembly Installed (Alternator with Jumper Wire Shown)

NOTE: Insulated screws (used on most alternators) have a one piece insulator permanently attached to screw body. Some alternators, however, may have insulated screws with only an insulating sleeve over screw body, and a separate insulating washer also is required. Install screw and insulating washer as shown in Figure 25.

CAUTION: Two insulated screws and ground screw MUST BE installed as shown in Figure 24 and 25. If ground screw and either of the insulated screws are reversed (or if insulating washers are missing), a ground will result, causing no output or uncontrolled output.

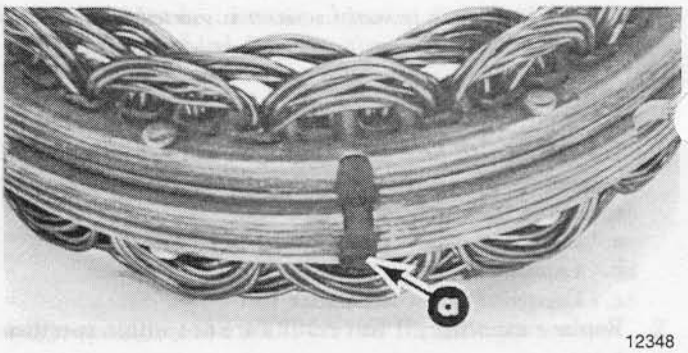
13. On alternators so equipped, connect jumper wire (installed in Step 7) to terminal on regulator and secure with nut. (Figure 24) Torque nut to 14-18 in. lbs. (16-21kg-cm).



a - Insulated Screws
b - Insulating Sleeve (Attached to Screw)
c - Insulating Washer
d - Install Diode Trio Connector under Insulating Washer
e - Ground Screw

Figure 25. Installing Insulated Screws with 2-Piece Insulators

14. Install rubber plug into groove on outside edge of laminated core stator, as shown in Figure 26. Position stator in slip ring end frame with stator leads over rectifier bridge terminals. Install 3 stator lead attaching nuts (and spring washers, if so equipped). Torque nuts to 20-28 in. lbs. (23-32kg-cm). Rotate stator slightly, if necessary, to align 4 grooves in stator frame with thru bolt holes in end frame.
15. Remove tape that was placed over slip ring end frame bearing and rotor shaft bearing surface during disassembly. Clean bearing surface on rotor shaft to remove any residue, then align scribed marks on end frames (scribed during disassembly) and assembly alternator. DO NOT install thru bolts at this time.



a - Rubber Plug

Figure 26. Rubber Plug Installed in Stator Laminated Core

16. Remove toothpick or wire from brush holder (thru hole in slip ring end frame) to allow brushes to contact slip rings.
17. Install sponge rubber washer over battery ("BAT") terminal screw insulator. Place flame arrestor cover over slip ring end frame and install 4 thru bolts and ground clip. Torque bolts to 50 in. lbs. (58kg-cm).
18. On alternators with a removable slip ring end frame flame arrestor screen, reinstall screen (if removed) and secure with 7 screws and lockwashers. Torque screws to 18-24 in. lbs. (21-28kg-cm).

SAFETY WARNING: ALL 7 slip ring end frame flame arrestor screen attaching screws MUST BE installed, or alternator will not be properly flame-arrested.

19. On 3-wire alternator only: Plug regulator terminal connector into slip ring end frame and secure with attaching bracket and 2 nuts. Tighten nuts securely.

ALTERNATOR INSTALLATION

1. Position alternator in mounting bracket and install mounting bolt, washers (if used), spacer and nut. Place washers (if used) on each side of spacer. DO NOT tighten nut at this time.
2. Fasten alternator brace to alternator with bolt, washers and spacer (if used). DO NOT tighten at this time.
3. Place alternator drive belt on pulleys and adjust tension as explained under "Drive Belt Replacement and/or Tension Adjustment", preceding. (See "Index".)

SAFETY WARNING: DO NOT use an open flame when installing heat shrink tubing (in next step) to prevent the possibility of an explosion and/or a fire.

4. Reconnect wiring harness to alternator. On 3-wire alternators, insulate red lead and white lead bullet connections with heat shrink tubing or at least 4 layers of electrical tape.
5. Reconnect battery cables to battery.

MC 470 ALTERNATOR SYSTEM
With Air-Cooled Voltage Regulator

Stator

TESTING

1. Disconnect battery cables from battery.
2. Disconnect stator wires from rectifier and terminal block.
3. Connect ohmmeter between 2 stator yellow/red wires. Meter should read .28 ohms (about ¼ ohm on most service meters).
4. Systems with 3 stator wires: Connect ohmmeter between either stator yellow/red wire and white/black wire. Meter should read 2.6 ohms.
   Systems with 4 stator wires: Connect ohmmeter between 2 white/black wires. Meter should read 2-6 ohms.
5. Check for continuity between stator wires and ground. There should be NO continuity.
6. Replace stator assembly if not within specifications.

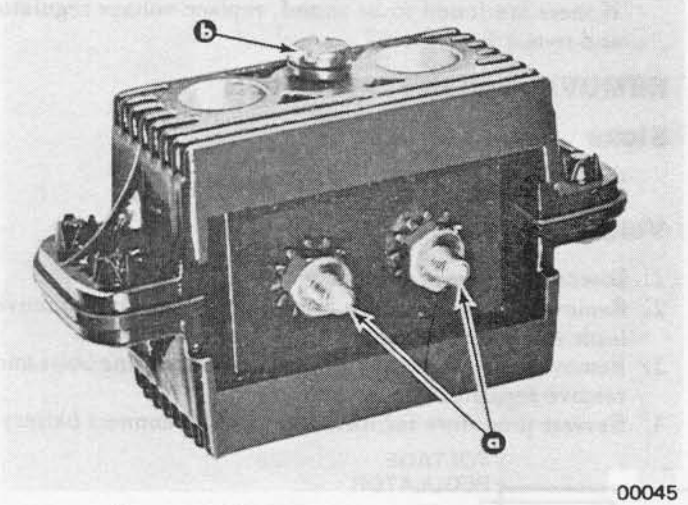
REMOVAL and INSTALLATION

For stator removal and installation, refer to Section 5D, "Engine Mechanical".

Rectifier

TESTING

1. Disconnect all wires from rectifier assembly.
2. To check positive diodes, connect continuity meter between one rectifier alternator terminal and rectifier positive terminal. (Figure 1) Check meter movement. Reverse test leads and check meter movement. Meter should show movement (continuity) with leads in one position and no movement (very low continuity) in other position. If both readings are very low, or both are very high, the diode is defective. Repeat this procedure for the other rectifier alternator terminal to check the other positive diode.
3. To check negative diodes, connect continuity meter between one rectifier alternator terminal and rectifier ground bolt. (Figure 2) Check meter movement, then reverse leads and check movement again. If both readings are very low, or both are very high, diode is defective. A good diode will give one high reading and one low reading. Repeat this procedure for the other negative diode by checking through the other rectifier alternator terminal.
4. Connect meter between rectifier alternator terminals. (Figure 2) Meter should indicate NO continuity.
5. Replace rectifier, if found defective in these tests.



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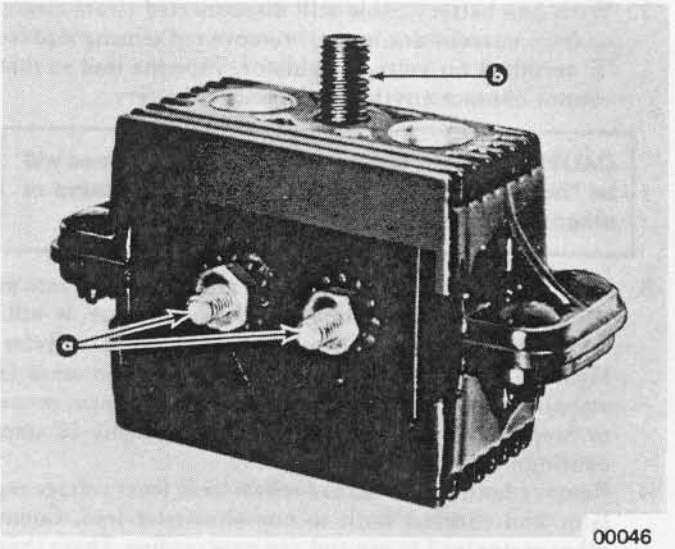
a - Alternator Terminals b - Positive Terminal

Figure 1. Testing Positive Diodes



00046

a - Alternator Terminals b - Ground Bolt

Figure 2. Testing Negative Diodes

REMOVAL and INSTALLATION

1. Refer to Section 3E for wiring connections.
2. Make sure that battery is disconnected before disconnecting or connecting any wires on rectifier. Replacement is a nut-and-bolt operation.

Regulator

TESTING

1. With regulator leads disconnected, continuity should not exist between regulator leads or between either lead and metal base. Since regulator is completely enclosed, no practical method to check unit with test instrument exists.
2. If none of previous checks shows any defects, and stator and rectifier test OK, replace regulator.

REMOVAL and INSTALLATION

1. Refer to Section 3E for wiring connections.
2. Make sure that battery is disconnected before disconnecting or connecting any regulator wires. Replacement is a nut-and-bolt operation.

MC 470 ALTERNATOR SYSTEM
With Water-Cooled Voltage Regulator

TESTING

NOTE: The battery is the most frequent cause of trouble in any charging system. With a system employing high-reliability components, such as this system, the probability of the battery being the cause of trouble is greater. Before beginning test procedure, fully charge and test the battery or install a fully-charged battery known to be good.

1. Inspect battery cable connections and connections of wires to voltage regulator. (If frequent battery discharge is the problem, check for current drain by connecting an ammeter between one battery cable end and its corresponding battery post.)
2. With one battery cable still disconnected (from cleaning or from current drain test), remove red sensing lead from 'S' terminal on voltage regulator. Tape the lead so that it cannot contact anything. Reconnect battery.

CAUTION: When battery is connected, this lead will be "hot". It must not be allowed to touch ground or other terminals.

3. Operate engine at 1000 RPM and note maximum amp output. (If boat is not equipped with an ammeter, it will be necessary to connect a shop unit to the system. Refer to Figure 1.) The ammeter should read about 25 amps (± 5 amps). If ammeter reading is within this range, proceed to Step 7. If ammeter reading is low (usually 12 amps), continue to next step.
4. Remove both stator leads (yellow/red) from voltage regulator and connect both to one ohmmeter lead. Connect other meter lead to ground and note reading. There should be NO CONTINUITY indicated.
5. Connect ohmmeter leads to the stator (yellow/red) leads separately and note reading. Since stator resistance is very low (.10-.25 ohms), a numerical reading is difficult to obtain. Therefore, while watching meter, alternately touch leads together (for zero ohms, regardless of meter setting) and separate them (for relative resistance). There should be very slight movement of the needle when touching and then separating leads. If stator is found to be grounded (Step 4) or shorted or open (as tested here), replace stator and re-test from Step 3. If stator is found to be neither open nor grounded, proceed to next step.
6. With all wiring in place, except red sensing lead (which is taped safely away from any possible contact with ground or other point), operate engine at 1000 RPM. Connect one lead of an AC voltmeter to the regulator ground (-) terminal and the other to one of the stator lead terminals (No. 1 or 2). Note reading on 0-40 VAC scale and move lead from that stator terminal to the other. If readings are the same, the stator is defective and must be replaced. If considerable variance exists between meter readings, (approximately 2:1 ratio), the voltage regulator is defective and must be replaced.
7. If max. reading in Step 3 was between 20 and 30 amps, replace all connections and connect a DC voltmeter to the battery terminals. Crank engine and run at 1000 RPM while watching voltmeter and ammeter. Proceed in accordance with one of the 4 possibilities, following:
   a. Amperage cuts back to 50% or less of maximum as battery reaches 14.3 ± .5 VDC: Correct operation - no further attention required.
   b. Battery voltage exceeds 14.3 ± .5 VDC: Overcharging condition - proceed with Step 8.
   c. Amperage cuts back to 50% or less of maximum, and battery remains below 14.3 ± .5 VDC: Undercharging condition - proceed with Step 8.
   d. None of the above occur within 10 minutes of operation: Battery state of charge is too low for test - recharge battery and return to beginning of Step 7.
8. If incorrect regulation of the charging was detected in preceding step, closely recheck connections of voltage regulator sensing lead, positive output lead and negative lead. If these are found to be sound, replace voltage regulator and re-test from Step 2.

REMOVAL and INSTALLATION

Stator

See Section 5D, "Engine Mechanical".

Voltage Regulator

1. Disconnect battery cables.
2. Remove nuts, that secure 5 leads to regulator, and move leads away from regulator.
3. Remove 2 water hoses and 3 regulator mounting bolts and remove regulator.
4. Reverse procedure for installation and reconnect battery.

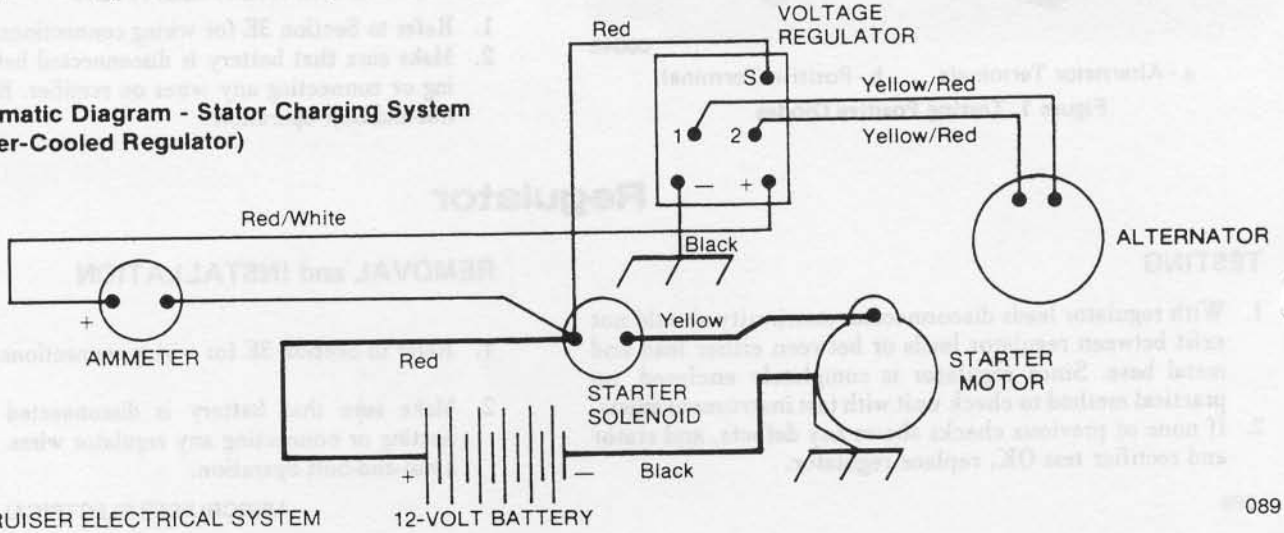
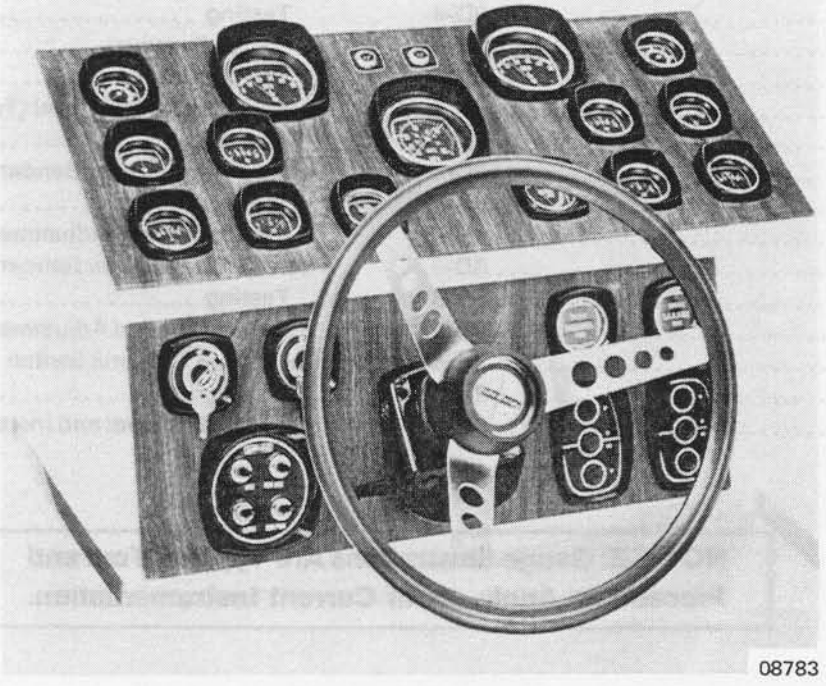


Figure 1. Schematic Diagram - Stator Charging System (Water-Cooled Regulator)

SECTION 3 - ELECTRICAL SYSTEM

PART D - INSTRUMENTATION



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NOTICE: Gauge Illustrations Are Typical. Text and Procedures Apply to All Current Instrumentation.

POWER TRIM GAUGE - TEMPERATURE GAUGE OIL PRESSURE GAUGE and FUEL GAUGE

Testing

1. With ignition switch on "Off", remove wire from stud marked "send" or "S" (this is wire coming from sending unit) on back of gauge. (Figure 1 or 2)

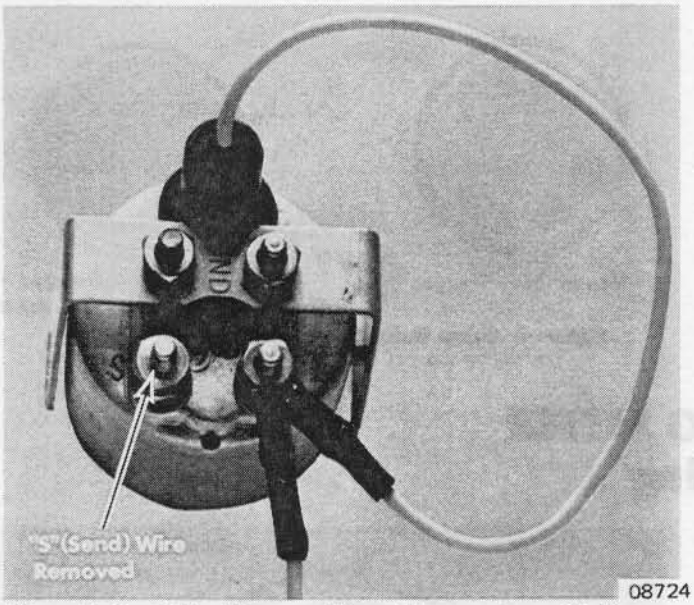


Figure 1. Send Wire Removed from Temperature, Oil Pressure and Fuel Gauges

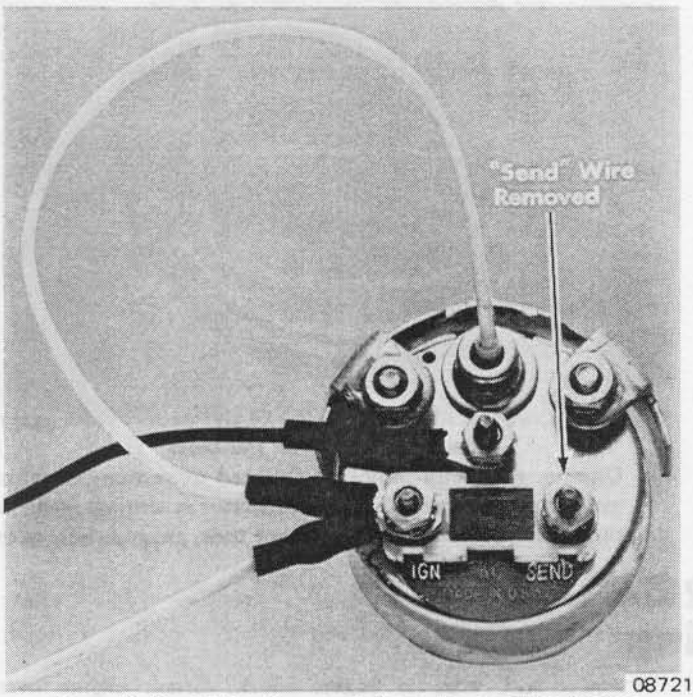


Figure 2. Send Wire Removed from Power Trim Gauge

2. Turn ignition switch to "Run" and note position of gauge indicator needle (should be in position shown in Figure 3). Turn ignition switch off.

3. With ignition switch in "Off" position, connect jumper wire from ground terminal to send (S) terminal. (Figure 4 or 5)

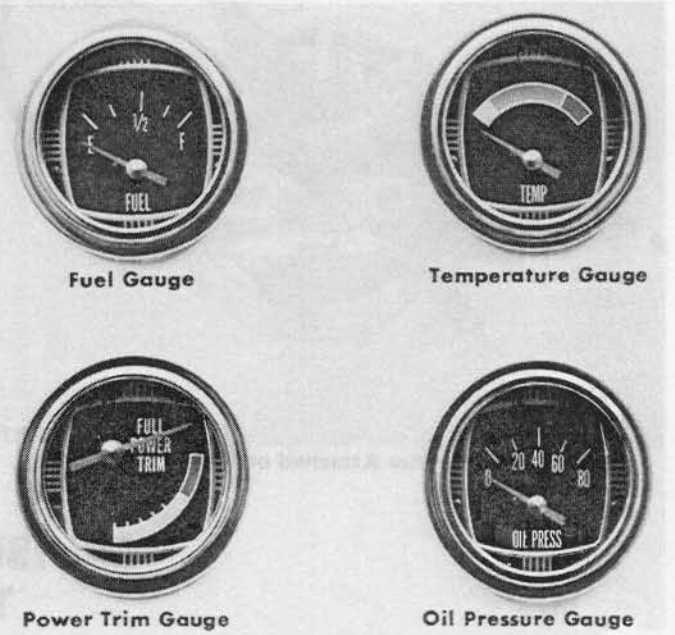


Figure 3. Gauge Indicator Needle Position (Step 2)

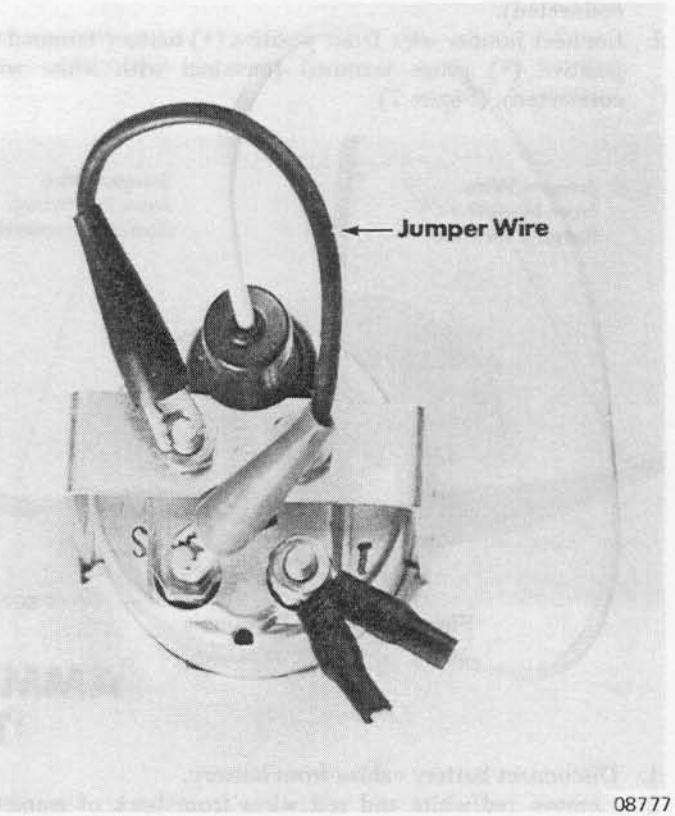


Figure 4. Jumper Wire Attached on Temperature, Oil Pressure or Fuel Gauge

4. Turn ignition switch to "Run" and note position of gauge indicator needle (should be in position shown in Figure 6). Turn ignition switch off. Replace gauge if indicator needle was not in positions shown in Figures 3 and 6.

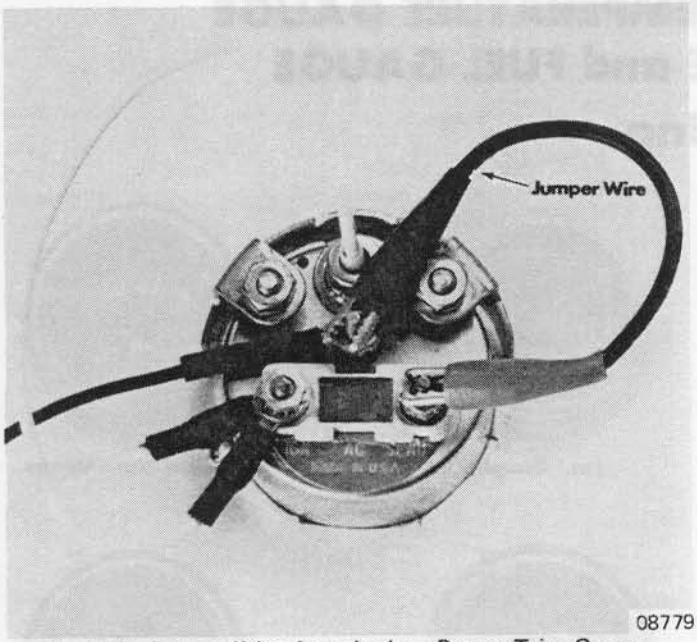


Figure 5. Jumper Wire Attached on Power Trim Gauge

Figure 6. Gauge Indicator Needle Position (Step 4)

CRUISELOG METER
Testing

1. Connect jumper wire from negative (-) battery terminal to negative (-) gauge terminal (terminal with black wire connected).
2. Connect jumper wire from positive (+) battery terminal to positive (+) gauge terminal (terminal with white wire connected). (Figure 7)

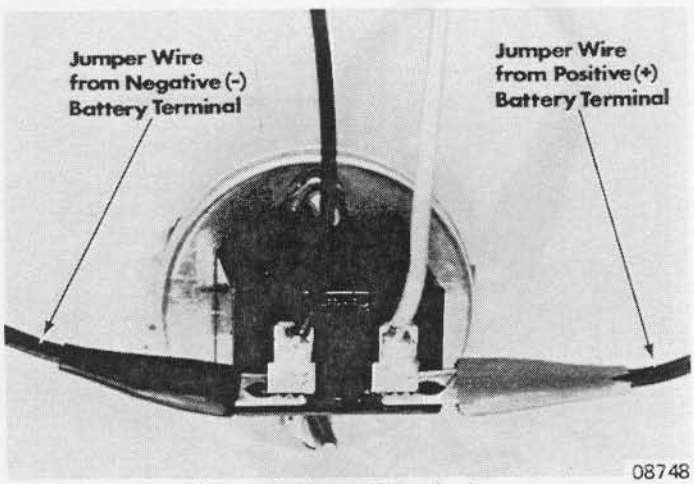


Figure 7. Gauge Terminals

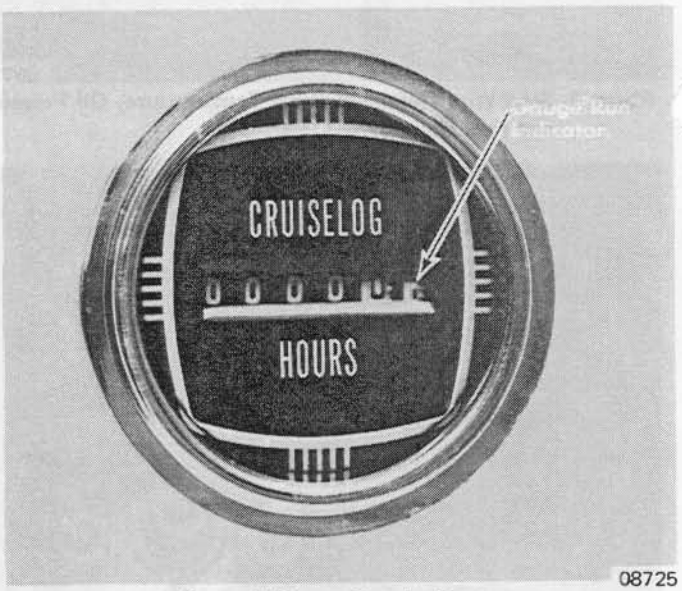


Figure 8. Gauge Run Indicator

3. Observe gauge run indicator (located at extreme right of gauge face). (Figure 8) If run indicator is turning, gauge is operable. If run indicator does not turn, gauge is defective.

AMMETER GAUGE
Testing

1. Disconnect battery cables from battery.
2. Remove red/white and red wires from back of ammeter gauge.
3. Connect positive (+) lead of service ammeter to red/white wire (removed from gauge) and connect negative (-) lead of service ammeter to red wire (removed from gauge). DO NOT allow wires to contact metal, other wires or terminals.
4. Connect battery cables to battery. Ground engine high tension coil wire to engine block. Crank engine over approximately 10 seconds (to remove battery surface charge), then reconnect coil wire, start engine and run at approximately 3000 RPM while observing service ammeter. Ammeter should be registering alternator output. If charging system is in working condition (see Trouble-shooting "Charging System" in Section 10), and service ammeter registers but ammeter gauge did not register, gauge is defective.

Removal

1. Disconnect battery cables from battery.
2. Remove red/white, red and black (if not mounted in metal panel) wires from back of gauge. (Figure 9)
3. Disconnect light socket.
4. Remove holding strap and remove gauge. (Figure 9)

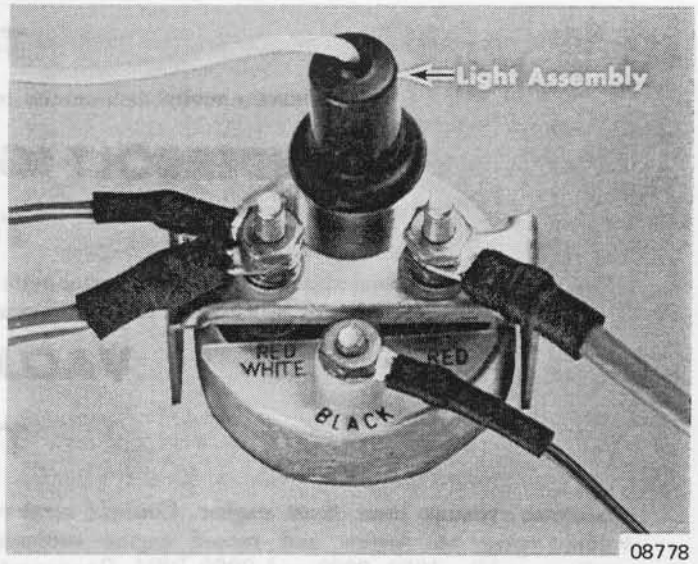


Figure 9. Ammeter Wire Connections

Installation

1. Position gauge assembly in appropriate mounting hole.
2. Install holding strap and nuts. Tighten nuts evenly and securely. (Figure 9)
3. Connect ground (black) wire to ground terminal, if gauge is not mounted in metal panel.
4. Connect red/white and red wires to terminals shown in Figure 9.
5. Install gauge light socket.
6. Coat all terminals with Neoprene (C-92-25711).
7. Reconnect battery cables to battery.

BATTERY METER

Testing

1. Remove wires from back of gauge.
2. Use fully charged 12-volt battery. Connect jumper lead from battery negative (-) terminal to gauge ground terminal. (Figure 10) Connect jumper lead from battery positive (+) terminal to gauge positive (+) terminal. (Figure 10) Gauge should read at beginning of green arch with battery that has 12.6 volts. Battery charge can be checked with service voltmeter.

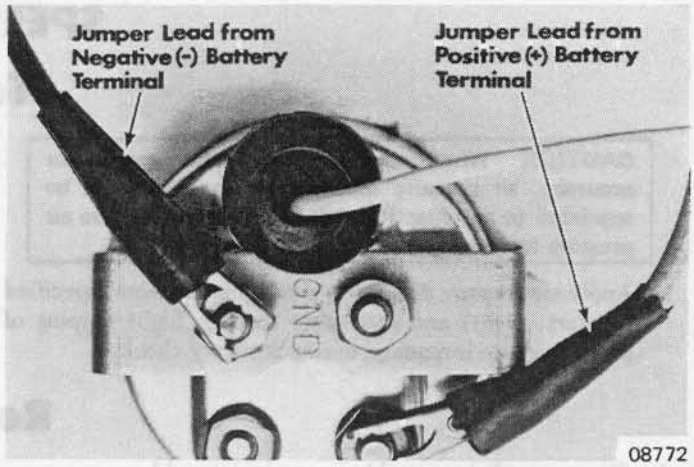


Figure 10. Jumper Leads to Battery Meter

Removal

1. Remove wires from ground and positive (+) terminals on gauge. Disconnect light wire.
2. Remove 2 nuts and holding strap.
3. Remove gauge assembly.

Installation

1. Position gauge assembly in appropriate mounting hole.
2. Install holding strap and nuts. Tighten nuts evenly and securely.
3. Connect ground (black) wire to gauge ground terminal.
4. Connect positive (white) wires to gauge positive (+) terminal and connect light wire.
5. Coat all terminals with Neoprene (C-92-25711).

STANDARD IGNITION TACHOMETER

Testing

Connect a service tachometer to engine and compare tachometer readings.

THUNDERBOLT IGNITION TACHOMETER

Testing

Thunderbolt Tachometer is tested with Thunderbolt Ignition Analyzer (C-91-62563A1). Follow test instructions in Test Manual (C-90-62900) which is supplied with analyzer.

VACUUM GAUGE

Testing

1. Disconnect vacuum hose from engine. Connect service vacuum gauge to engine and record engine vacuum readings at idle, 1000, 2000 and 3000 RPM. Reconnect vacuum hose and compare vacuum gauge readings (at specified RPM) with service gauge readings. Readings should be within 3 inches of vacuum of each other.

NOTE: Make sure that vacuum hose between gauge and engine is not leaking and that all connections are tight.

Removal

1. Disconnect gauge light and gauge vacuum hose.
2. Remove holding strap and gauge.

Installation

1. Position gauge assembly in appropriate mounting hole.
2. Install holding strap and nuts. Tighten nuts evenly and securely.
3. Connect gauge light and vacuum hose.

SPEEDOMETER

Testing

CAUTION: When testing speedometer gauge for accuracy, air pressure that is used for test must be regulated to specified PSI. DO NOT apply excessive air pressure to speedometer gauge.

1. Apply air pressure directly to speedometer gauge (specified in chart, right) and note gauge reading. Light tapping of pressure gauge is required during accuracy check.

CALIBRATION CHART

Air Pressure Gauge PSI	Speedometer Gauge MPH
5.3 (.37kg/cm^2)	20 ± 1 (32km/hr± 1.6)
27.8 (1.95kg/cm^2)	45 ± 1 (72km/hr± 1.6)

2. If gauge readings are not within specifications, gauge is defective.

Removal

1. Disconnect light assembly, ground wire and hose.
2. Remove holding brackets and remove gauge assembly.

Installation

1. Position gauge assembly in appropriate mounting hole.
2. Install holding brackets and nuts. Tighten nuts evenly and securely. DO NOT distort speedometer case or bracket by over-tightening.
3. Install hose, ground wire and light assembly. (Figure 1)

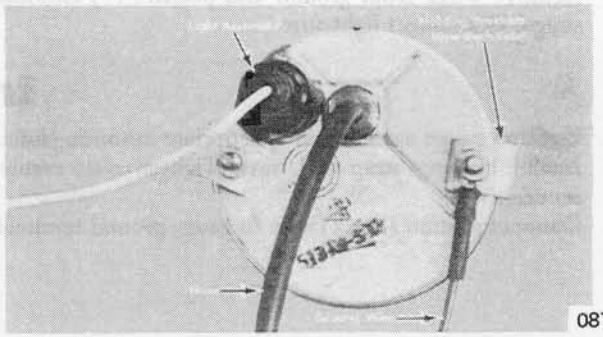


Figure 1. Speedometer Gauge Connections

OIL PRESSURE SENDER

Testing

CAUTION: Use following test procedure for checking accuracy of oil pressure sender only. If oil pressure gauge indicates zero oil pressure, refer to "Engine Oil Pressure" in "Troubleshooting" Section 10.

1. Remove wire from sender terminal.
2. Connect ohmmeter between sender terminal and sender case. (Figure 2) Check ohms reading without engine running (zero pressure), then check reading with engine running. Compare oil pressure and ohms readings as shown in following chart:

Oil Pressure (Lbs./Sq. In.)	Ohms Reading	
	Single	Dual
0	227-257	113.5-128.5
20 (1.4kg/cm^2)	142-162.5	71-81.25
40 (2.8kg/cm^2)	91.7-113.6	45.8-56.8
80 (5.6kg/cm^2)	9-49	4.5-24.5

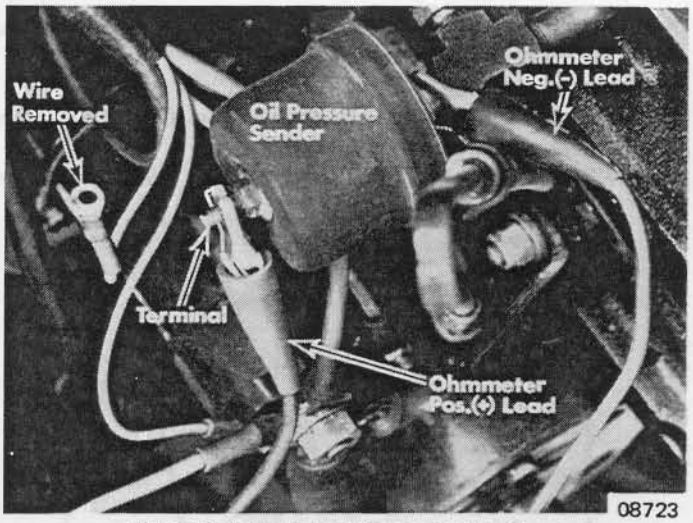


Figure 2. Ohmmeter Connected to Sender

Removal

1. Remove wire from sender terminal.
2. Remove sender from engine.

Installation

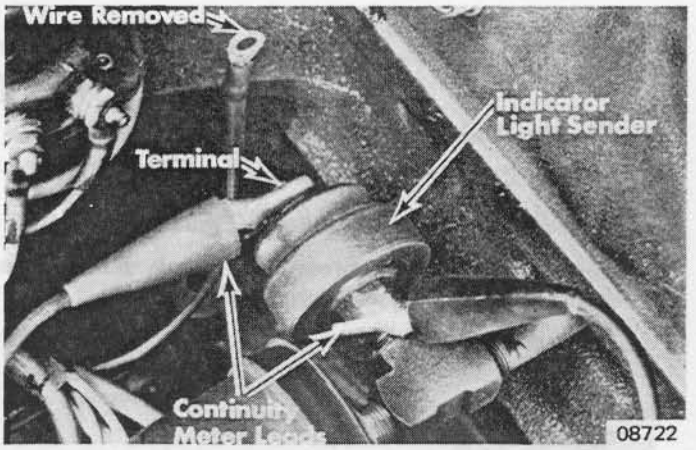
1. Coat threads of sender with Perfect Seal (C-92-34227) and install sender on engine.
2. Connect orange engine harness wire to sender terminal and coat terminal with Neoprene (C-92-25711).

INDICATOR LIGHT SENDER

Testing

1. Remove wire from sender terminal.
2. Connect continuity meter between sender terminal and metal portion of sender case. (Figure 3)
3. With engine not running, meter should indicate full continuity.
4. Start engine. With engine running and engine oil pressure above 6 PSI (.42kg/cm^2), meter should indicate NO continuity.

Figure 3. Continuity Meter Connected to Sender



Removal

1. Remove wire from sender terminal.
2. Remove sender from engine.

Installation

1. Coat threads of sender with Perfect Seal (C-92-34227) and install sender on engine.
2. Connect purple engine harness wire to sender terminal and coat terminal with Neoprene (C-92-25711).

TANK SENDING UNIT
Testing

1. Disconnect wire from terminal on sending unit and ground wire from sending unit mounting screw.
2. Remove sending unit from fuel tank.
3. Connect ohms meter between sending unit terminal and sending unit housing. (Figure 4)
4. With float arm in "full" position (arm horizontal), ohmmeter should read 30 ohms (+ or - 5 ohms). (Figure 4) With float arm in "empty" position (arm vertical) meter should read 240 ohms (+ or - 5 ohms). (Figure 5) Sender is defective if not within specifications.

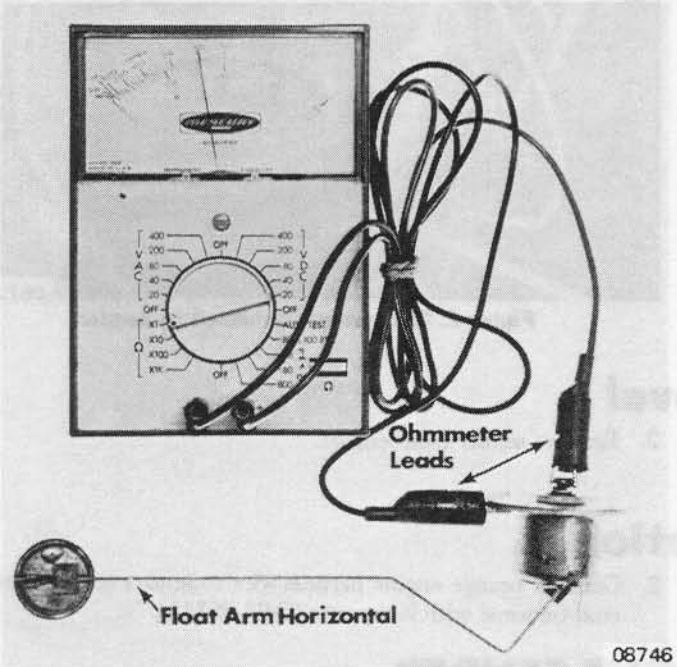


Figure 4. Ohmmeter Connected to Sender with Float Arm Horizontal

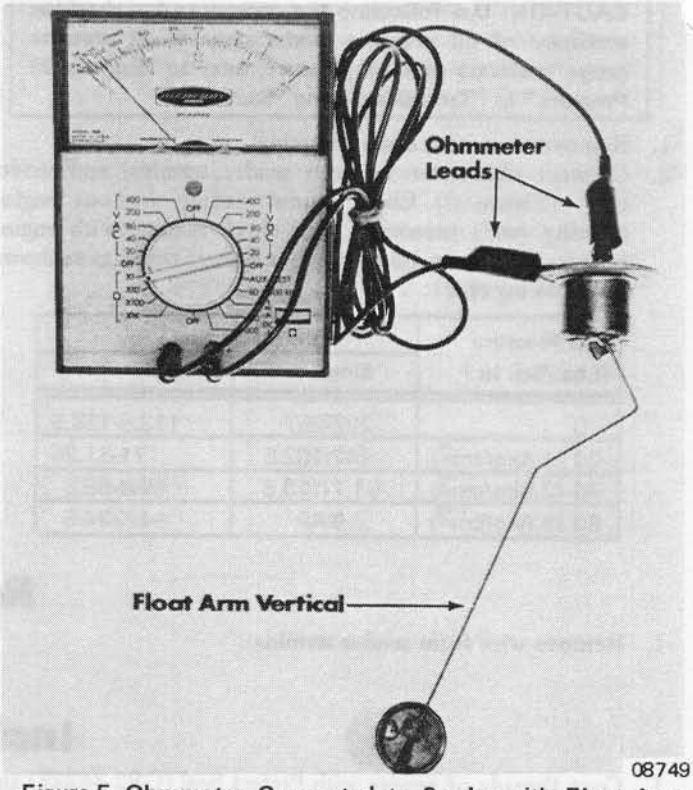


Figure 5. Ohmmeter Connected to Sender with Float Arm Vertical

ELECTRIC SENDER CAPSULE
Testing

1. Disconnect wire from terminal on fuel tank capsule.
2. Remove 2 screws and remove capsule assembly.
3. Place a magnet under fuel capsule. (Figure 6)
4. Connect ohmmeter between fuel capsule terminal and metal portion of capsule housing. (Figure 6)

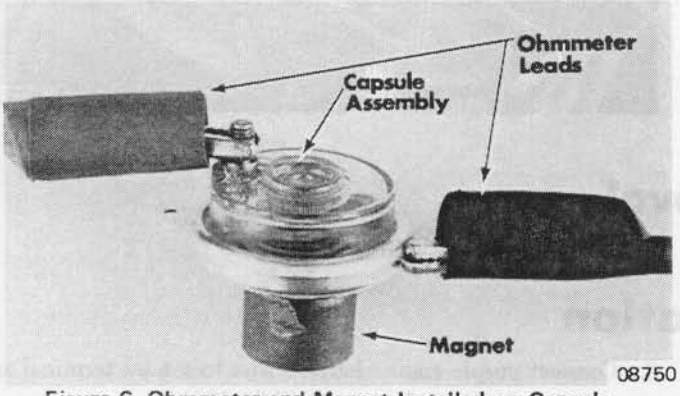


Figure 6. Ohmmeter and Magnet Installed on Capsule

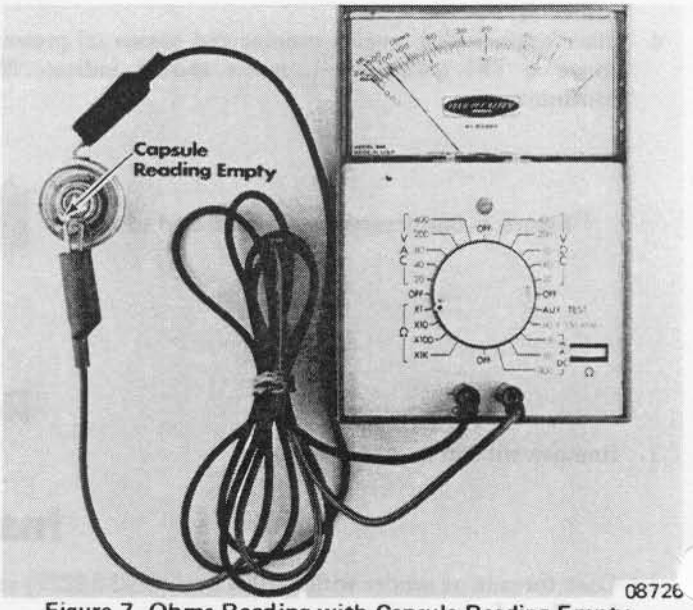


Figure 7. Ohms Reading with Capsule Reading Empty

5. Turn magnet counterclockwise until fuel capsule indicator reads empty. Ohmmeter should read 240 ohms (+ or - 5 ohms). (Figure 7)
6. Turn magnet clockwise until fuel capsule indicator reads "Full". Ohmmeter should read 30 ohms (+ or - 5 ohms). (Figure 8) Fuel capsule is defective if not within specifications.

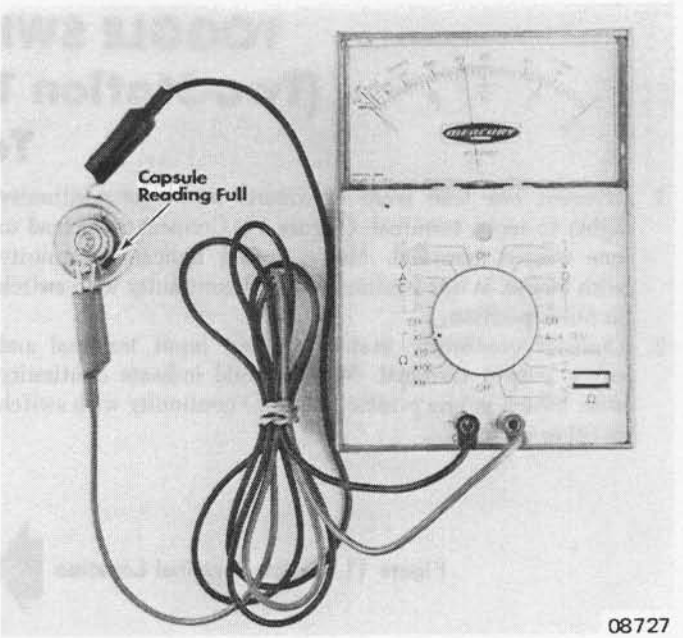


Figure 8. Ohms Reading with Capsule Reading Full

IGNITION KEY SWITCH
Testing

CAUTION: Disconnect battery cables from battery before testing ignition key switch with wires still connected to switch.

1. Before testing key switch, check all fuses and/or circuit breakers in electrical circuit which could prevent operation of starter. See Section 3, Part 'E', for schematic wiring diagrams.
2. With key switch in position "1" ("Off"), there should be no continuity between switch terminals. (Figures 9 and 10)
3. With key switch in position "2" ("Run"), continuity will exist between switch terminal "B" to "A" and "B" to "I". There should be no continuity between terminal "C" and any other terminals. (Figures 9 and 10)
4. With key switch in position "3" ("Start"), continuity will exist between terminal "B" to "A", "B" to "I" and "B" to "C". (Figures 9 and 10)
5. Terminals are to make contact at angles shown in Figure 9 and to stay in contact condition as switch is rotated toward position "3" ("Start").
6. If ignition key switch tests bad, unsolder wire connections and remove switch. Test switch again, as in Steps 2-thru-5, preceding. If switch tests good, wiring in harness is bad. There should be no continuity between any harness wires with key switch removed.

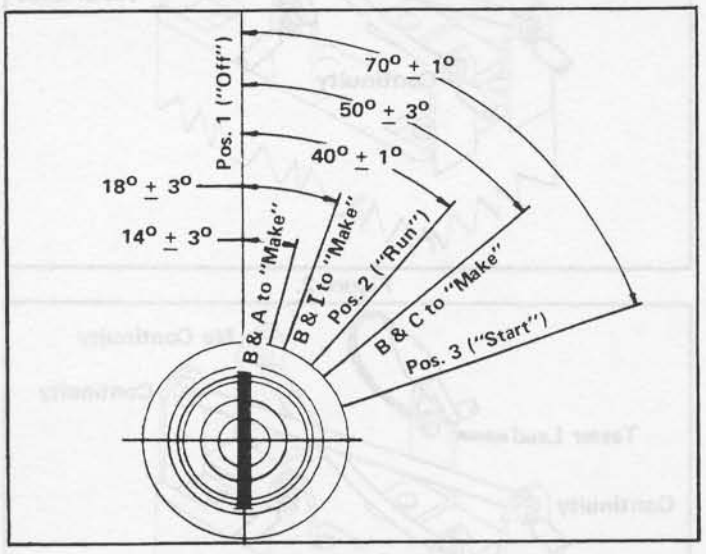


Figure 9. Ignition Switch Positions

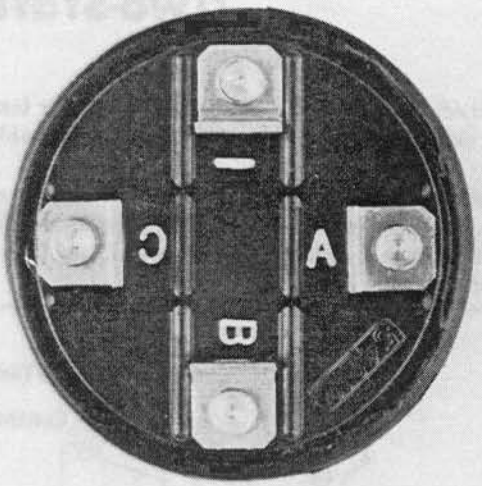


Figure 10. Switch Terminal Identification

TOGGLE SWITCH (Single Pole)
(Two-Station Tachometer Switch)
Testing

1. Connect one lead from continuity meter (or continuity light) to input terminal. (Figure 11) Connect other lead to one output terminal. Meter should indicate continuity with switch in one position and NO continuity with switch in other position.
2. Connect continuity meter between input terminal and other output terminal. Meter should indicate continuity with switch in one position and NO continuity with switch in other position.

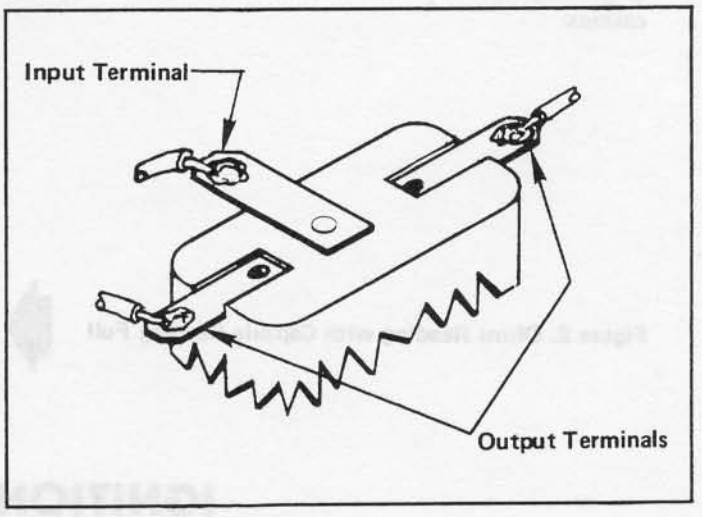


Figure 11. Switch Terminal Location

TOGGLE SWITCH (Double Pole)
(Two-Station Tachometer Switch)
Testing

1. Connect one lead from continuity meter (or test light) to one center pole on either side of switch assembly. (Figure 1)
2. Alternately connect other test lead to switch end terminals. With switch in one position, meter should indicate continuity at 2 switch poles (Figure 1) and NO continuity at other switch poles.

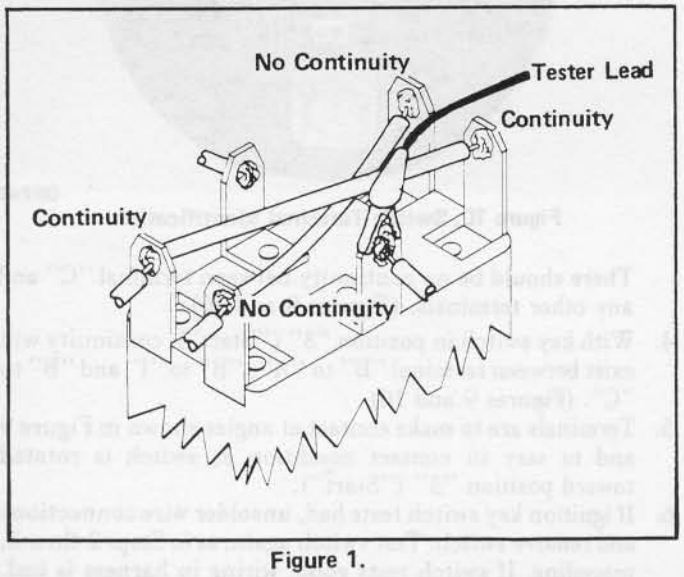


Figure 1.

3. Place switch in other position. Meter should indicate continuity at opposite poles indicated in Step 2. (Figure 2)
4. Connect one lead from continuity meter (or test light) to center pole on other side of switch assembly. (Figure 3)
5. Alternately connect other test lead to switch end terminals. With switch in one position, meter should indicate continuity at 2 switch poles (Figure 3) and NO continuity at other switch poles.
6. Place switch in other position. Meter should indicate continuity at opposite poles indicated in Step 5. (Figure 4)
7. Connect continuity meter (or test light) between 2 center terminals of switch. (Figure 5) At no time should continuity exist between center terminals with switch in either position.

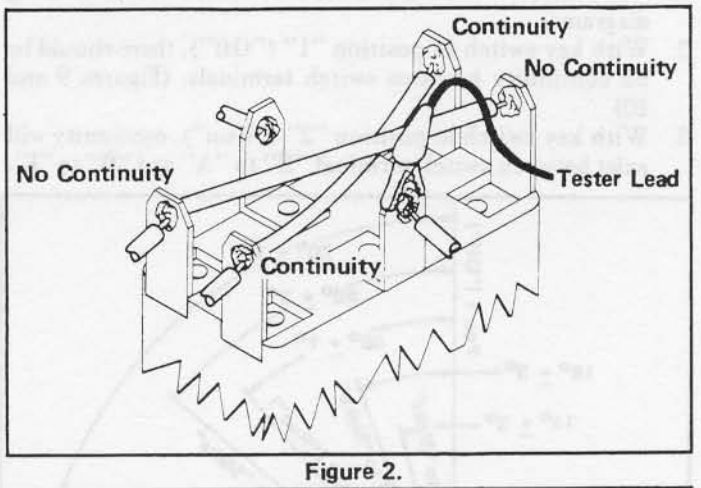


Figure 2.

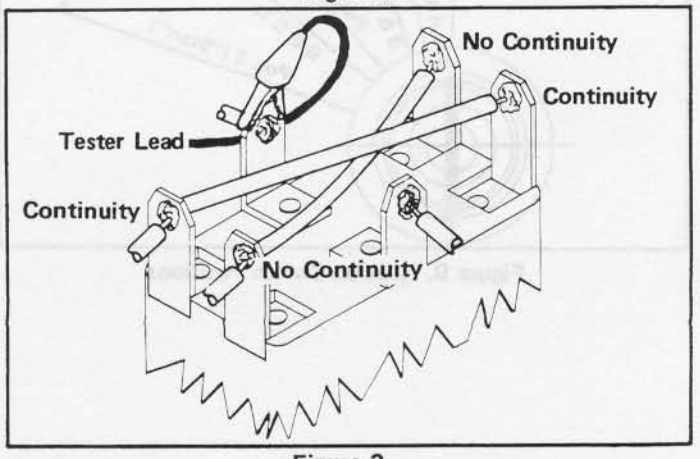


Figure 3.

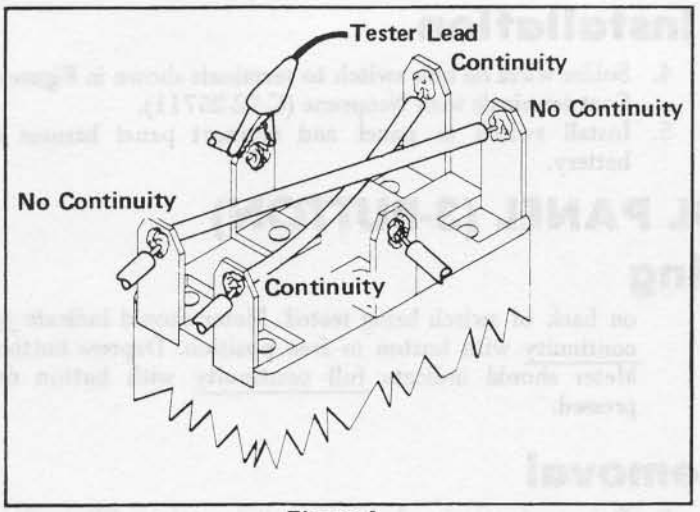


Figure 4.

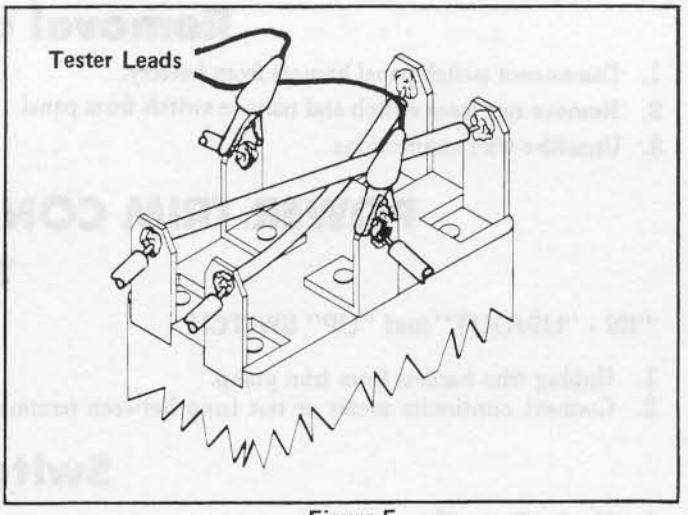
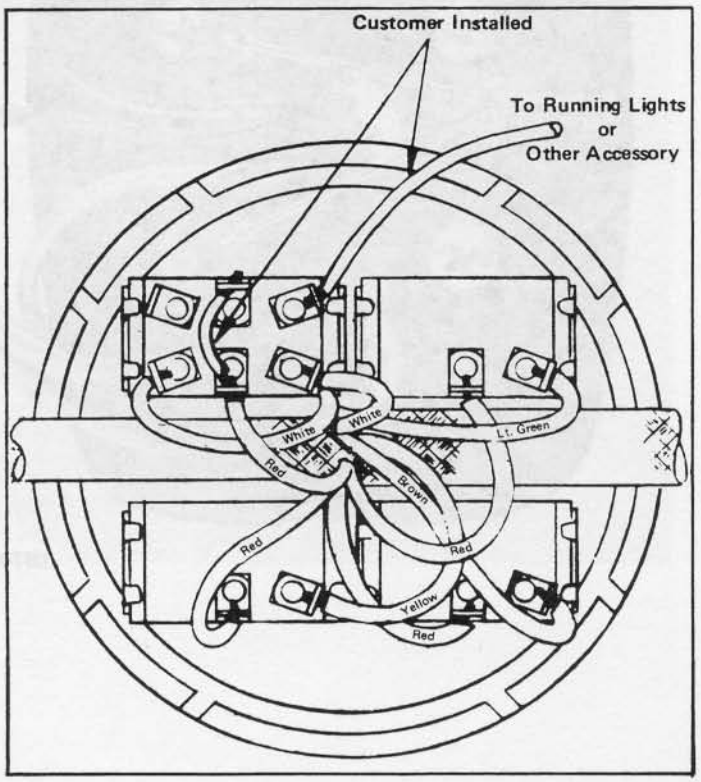


Figure 5.

SWITCH PANEL KIT
Testing

2-TERMINAL SWITCH

1. Disconnect switch panel harness from battery.
2. Connect continuity meter or test light between switch terminal (with red wire) and switch terminal (with wire leading to fuse block). (Figure 6)
3. There should be continuity between switch terminals with switch turned in one position and no continuity with switch turned in other position. If switch has continuity in both positions or no continuity in both positions, switch is bad.



6-TERMINAL SWITCH (Wired on One Side Only)

1. Disconnect switch panel harness from battery.
2. Connect continuity meter or test light (with one lead) to switch terminal (with red wire.). Place switch in center position. There should be no continuity between terminal with red wire and terminals (one each end) with white wires attached. (Figure 6)
3. Move switch in either direction to "On" position. There should be continuity between terminal with red wire and terminals (one each end) with white wires attached.
4. Move switch to other "On" position. There again should be continuity between terminal with red wire and terminals (one each end) with white wires attached.

6-TERMINAL SWITCH (Wired on Both Sides)

1. Perform test under "6-Terminal Switch (Wired on One Side Only)". If these tests check OK, continue with Step 2.
2. Connect continuity meter or test light between 2 center switch terminals. Meter should show continuity with switch in any position.
3. Connect continuity meter or test light between either terminal and end terminal with additional accessory wire attached. (Figure 6) With switch in center position, there should be no continuity. There should be continuity with switch in one "On" position but no continuity with switch in other "On" position.

Figure 6. Switch Panel Wiring

Removal and Installation

1. Disconnect switch panel harness from battery.
2. Remove nut from switch and remove switch from panel.
3. Unsolder wire connections.
4. Solder wires on new switch to terminals shown in Figure 6. Coat terminals with Neoprene (C-92-25711).
5. Install switch in panel and connect panel harness t battery.

POWER TRIM CONTROL PANEL (3-BUTTON)

Testing

"IN - "UP/OUT" and "UP" SWITCH

1. Unplug trim harness from trim pump.
2. Connect continuity meter or test lamp between terminals on back of switch being tested. Meter should indicate no continuity with button in free position. Depress button. Meter should indicate full continuity with button depressed.

Switch Removal

1. Unplug Power Trim harness from trim pump.
2. Remove control panel from its mounting hole.
3. Remove 4 screws and remove switch retainer. (Figure 7)
4. Unsolder wire connections from switch being replaced.

Switch Installation

1. Solder wires on new switch to terminals shown in wiring diagrams of Section 3E. Coat terminals with Neoprene (C-92-25711).
2. Place switch in panel and install switch retainer. (Figure 7)
3. Install control panel in its mounting hole.
4. Connect Power Trim harness to trim pump.

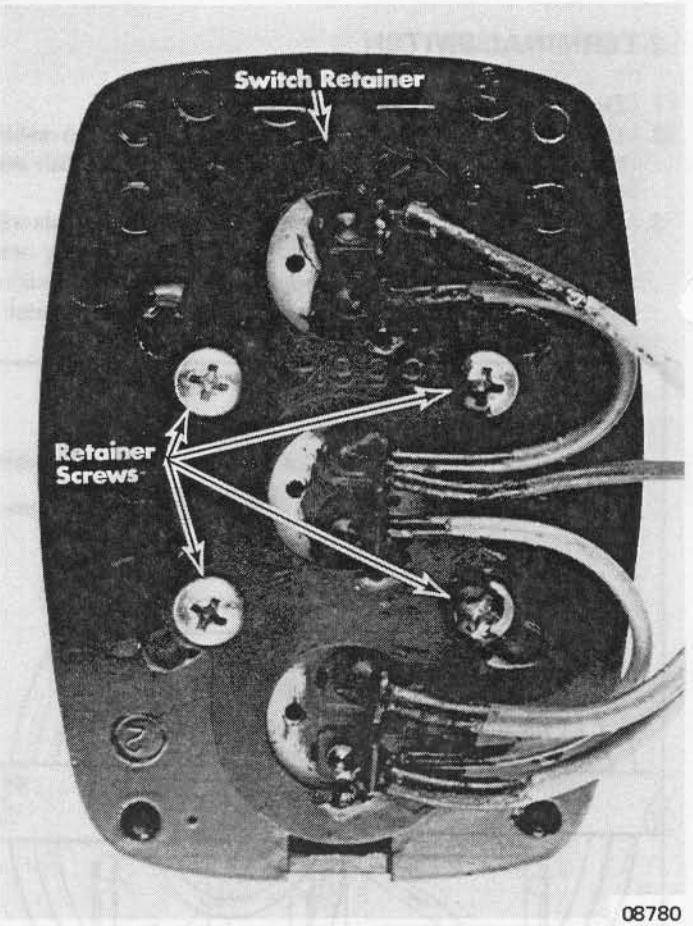


Figure 7. Switch Removal and Installation

POWER TRIM CONTROL PANEL (TOGGLE SWITCH)

Testing

1. Unplug Power Trim harness from trim pump.
2. Connect continuity meter or test light between terminals of "Trailer" button. Meter should indicate no continuity. With button depressed, meter should show full continuity.
3. Connect continuity meter or test light between terminals 'B' and 'C'. (Figure 8) There should be full continuity. If no continuity exists, check fuse before replacing switch.
4. With toggle switch centered, connect meter between terminals 'A' and 'C'. There should be no continuity. Press toggle switch down (trim in). There now should be full continuity. Repeat procedure between terminals 'B' and 'D'. There should be no continuity with toggle switch centered and full continuity with switch pressed up (trim out). If results of any of these tests are not as stated, replace switch.

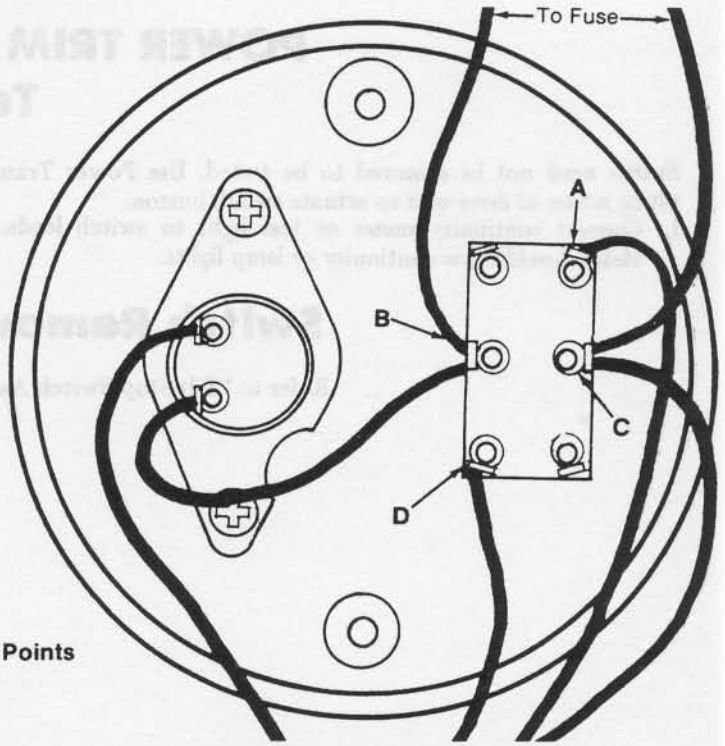


Figure 8. Toggle Switch Control Test Points

POWER TRIM INDICATOR SENDER (LINEAR)

Testing

1. Remove sender and connect sender leads to ohmmeter.
2. Push sender plunger in with pencil or similar object and note meter reading. Sender resistance should be approximately between zero and 160 ohms for single installations and between zero and 80 ohms for dual. If erratic or no needle movement is noted, replace and adjust new sender.

Installation and Adjustment

Refer to Section 7A.

POWER TRIM INDICATOR SENDER (ROTARY)

Testing

1. Remove sender and connect sender leads to ohmmeter.
2. Align mark on index shaft with mark on sender housing. (Figure 9) Meter should indicate an even movement of (approximately) between zero and 160 ohms for single and between zero and 180 ohms for dual. Further rotation will carry resistance valve beyond 160 ohms, which is normal. If erratic or no needle movement is noted, replace and adjust new sender.

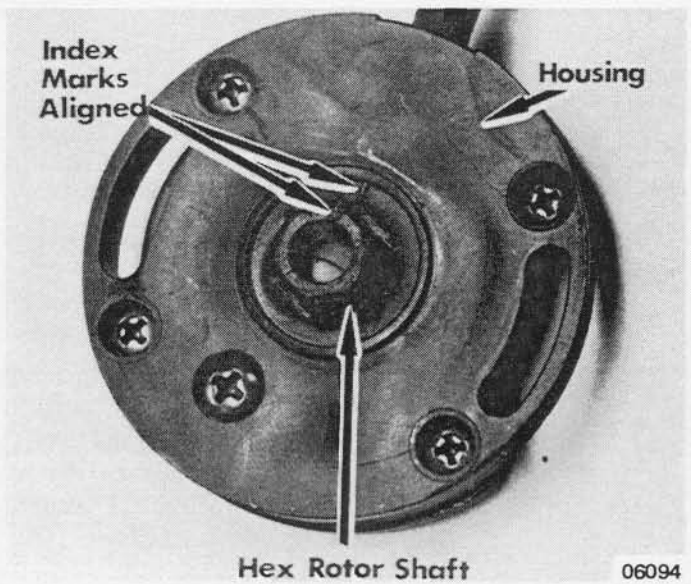


Figure 9. Index Marks Aligned

Installation and Adjustment

Refer to Section 6B and Section 7A.

POWER TRIM TILT LIMIT SWITCH

Testing

Switch need not be removed to be tested. Use Power Trim tilting action of drive unit to actuate switch button.

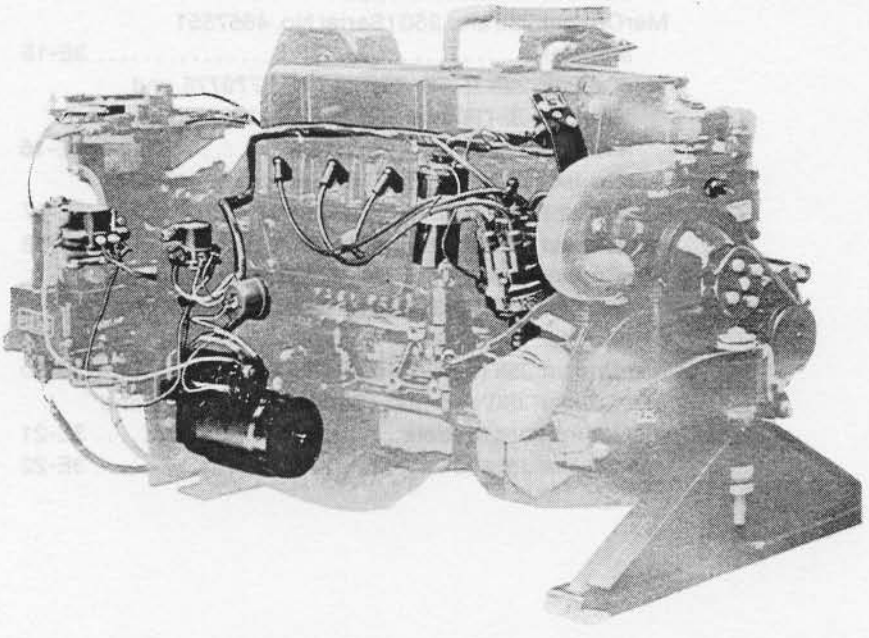
1. Connect continuity meter or test light to switch leads. Meter should show continuity or lamp lights.
2. Actuate Power Trim. Approximately 1/3 Power Trim travel, switch should open and meter should show NO continuity or lamp should NOT light.

Switch Removal and Installation

Refer to "Tilt Stop Switch Assembly - Removal - Installation" Section 6.

SECTION 3 - ELECTRICAL SYSTEM

PART E - WIRING DIAGRAMS



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MERCURY MARINE

A BRUNSWICK COMPANY

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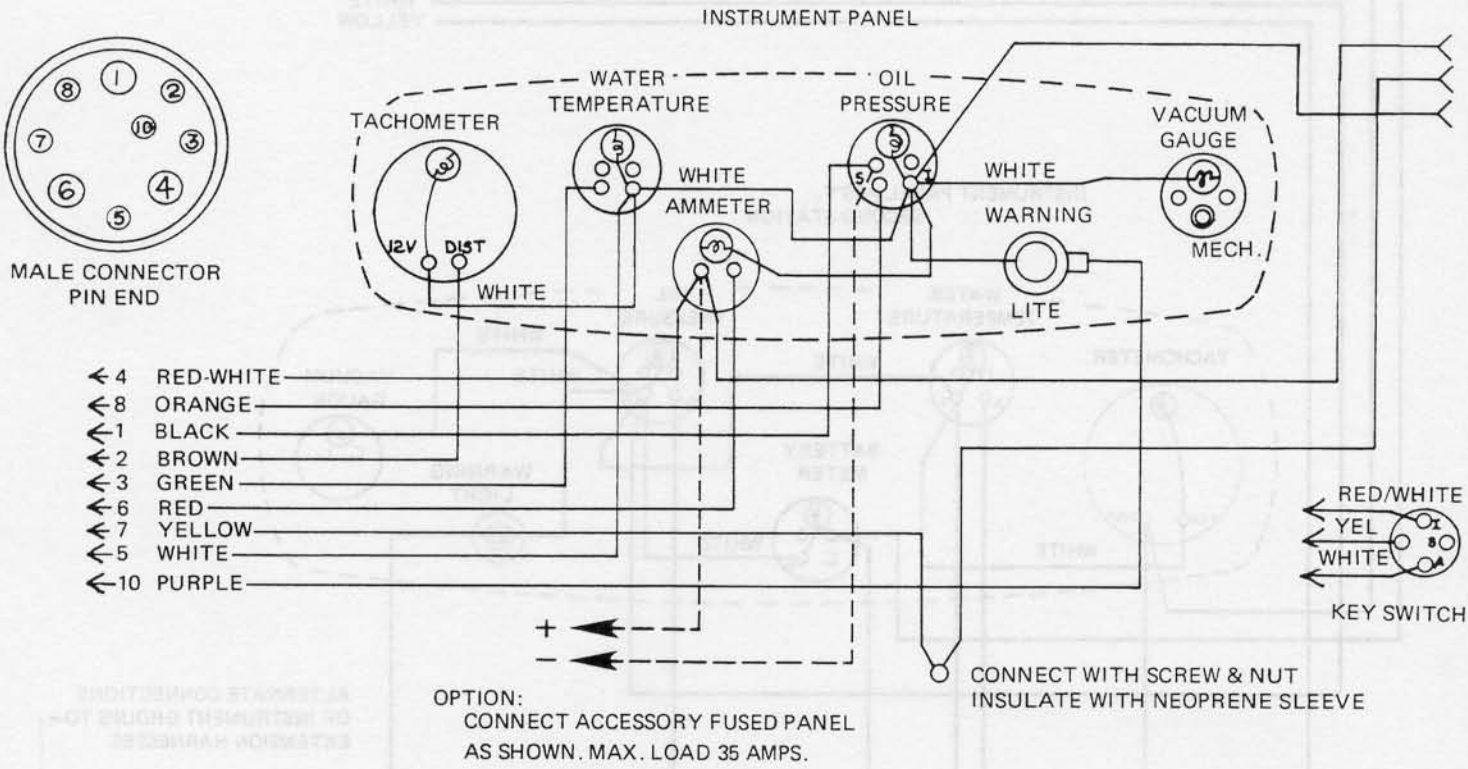
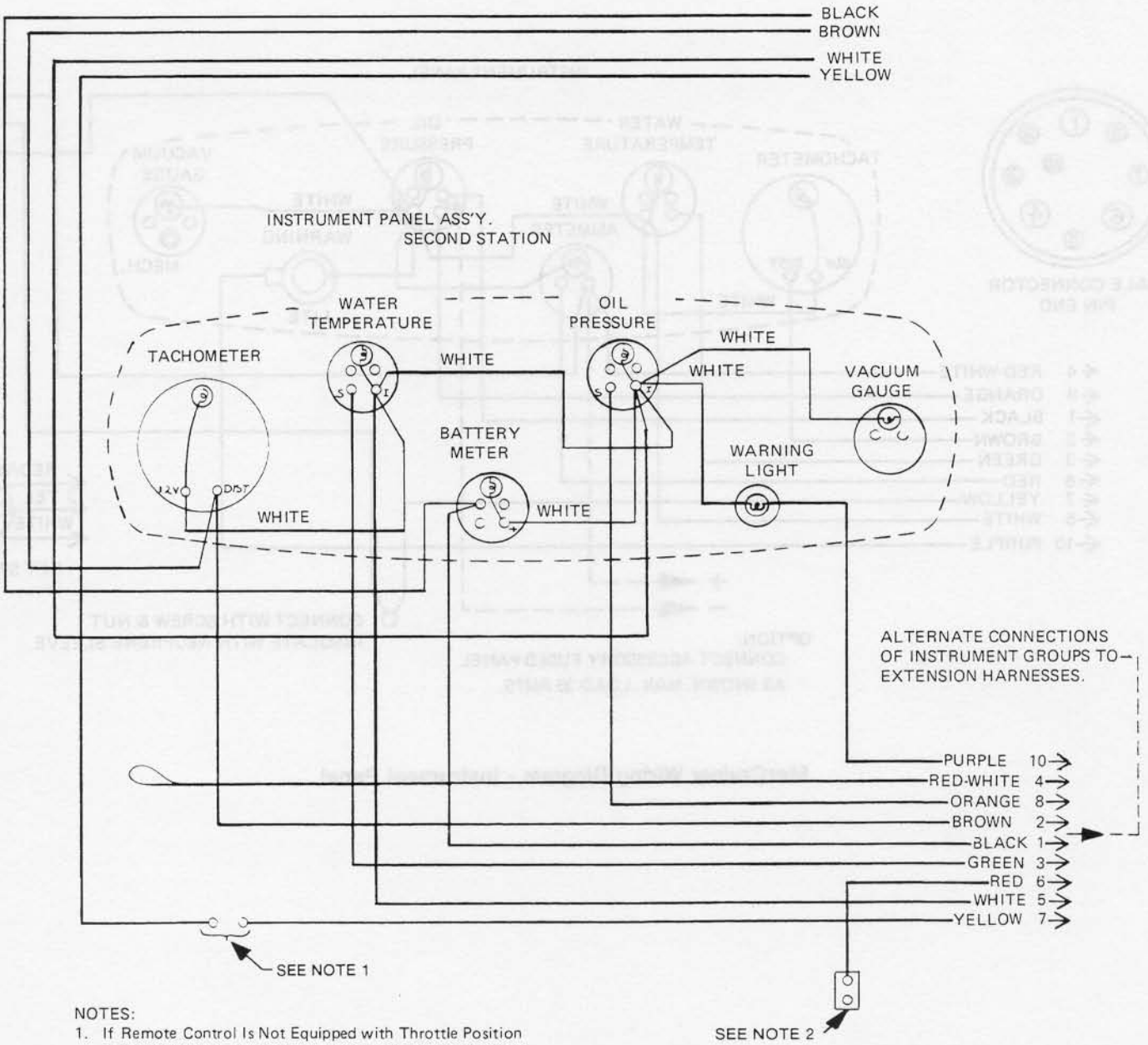


MerCruiser Wiring Diagram - Instrument Panel

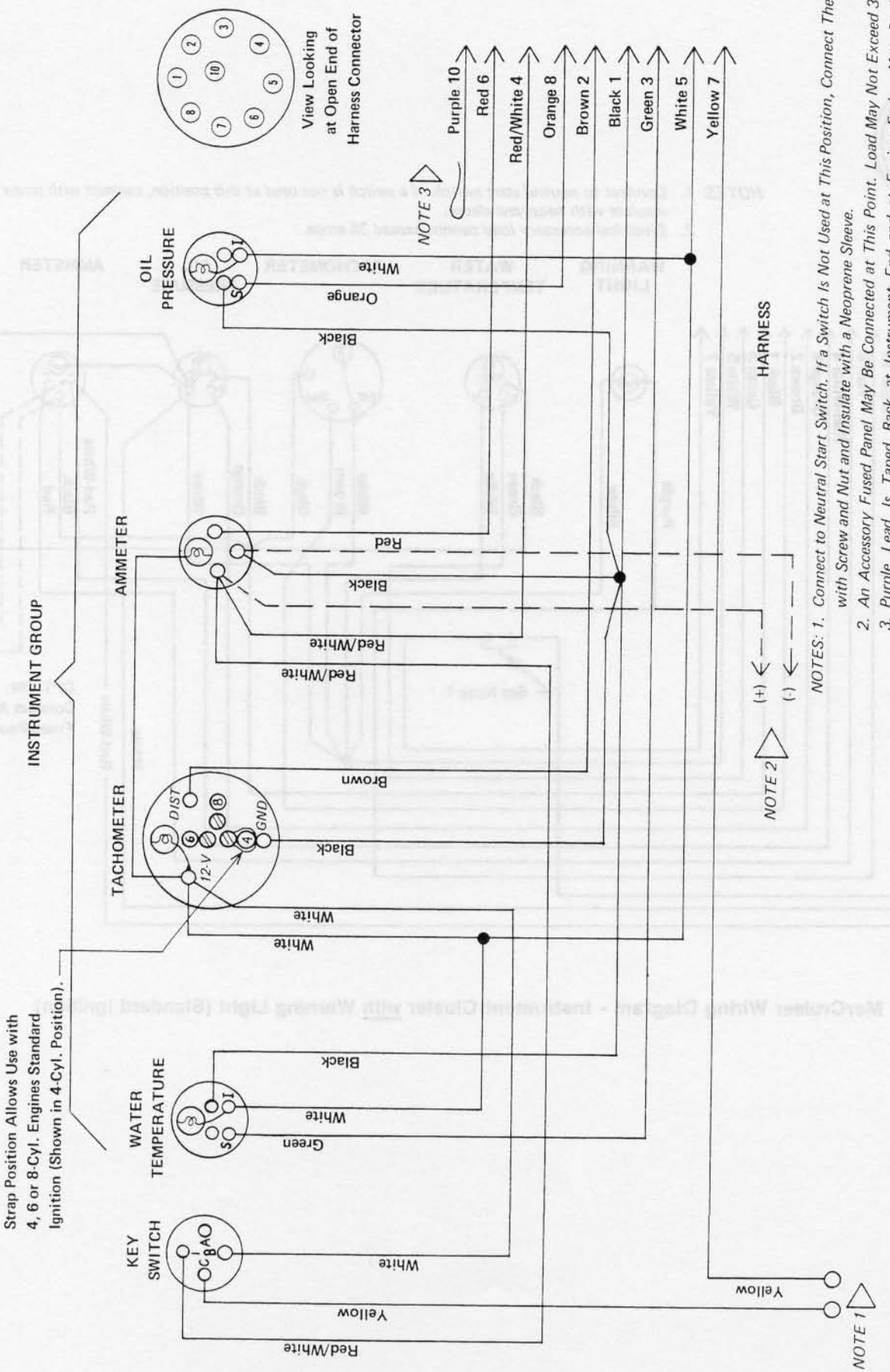


NOTES:

1. If Remote Control Is Not Equipped with Throttle Position Cut-Out Switch, (A) Connect Leads with Screw and Nut; Insulate with Neoprene, OR (B) Connect to Neutral Safety Switch. If a Switch Is Not Used at This Position, Connect with Screw and Nut; Insulate with Neoprene Sleeve.
2. The Sum of the Electrical Loads Drawn from the Upper and Lower Accessories Taps Cannot Exceed 35 Amps.

MerCruiser Wiring Diagram - Instrument Panel Second Station

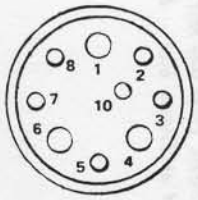
MerCruiser Wiring Diagram - Instrument Cluster without Warning Light (Standard Ignition)



NOTES: 1. Connect to Neutral Start Switch. If a Switch Is Not Used at This Position, Connect These Leads with Screw and Nut and Insulate with a Neoprene Sleeve.

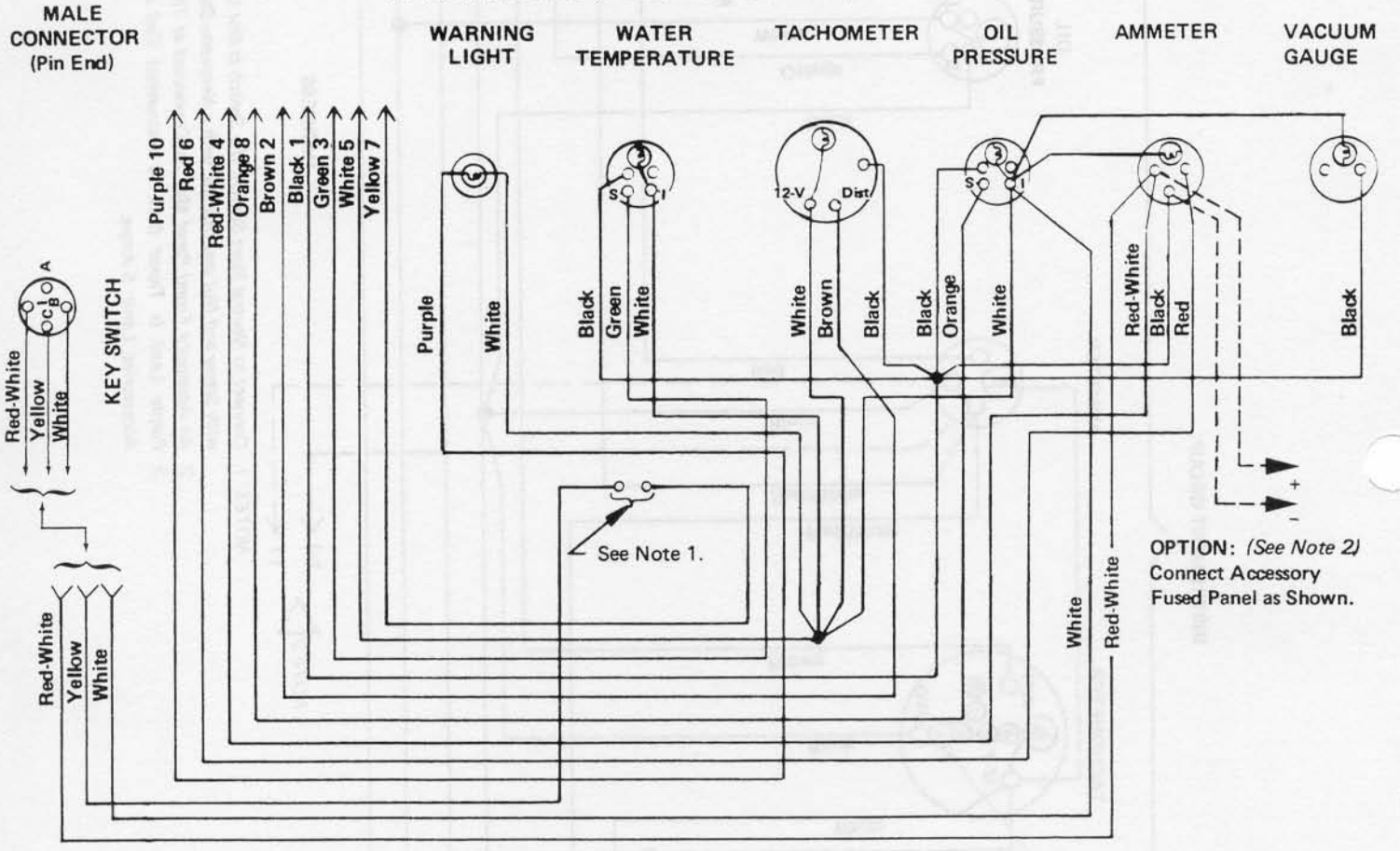
2. An Accessory Fused Panel May Be Connected at This Point. Load May Not Exceed 35 Amps.

3. Purple Lead Is Taped Back at Instrument End and at Engine End -- May Be Used for Accessories. Limit: 5 Amps.

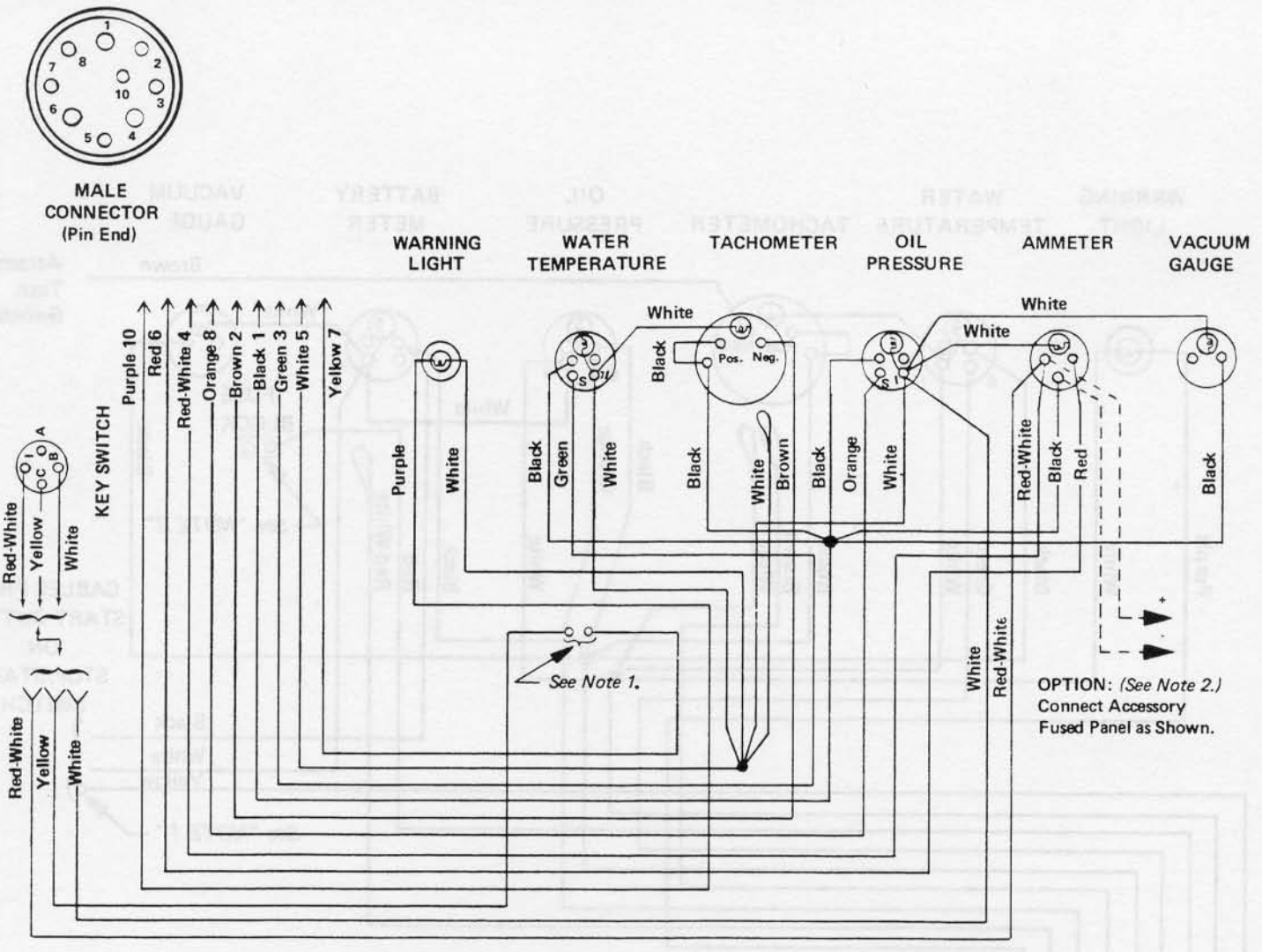


MALE CONNECTOR (Pin End)

NOTES: 1. Connect to neutral start switch. If a switch is not used at this position, connect with screw and nut and insulate with neoprene sleeve.
2. Electrical accessory load cannot exceed 35 amps.



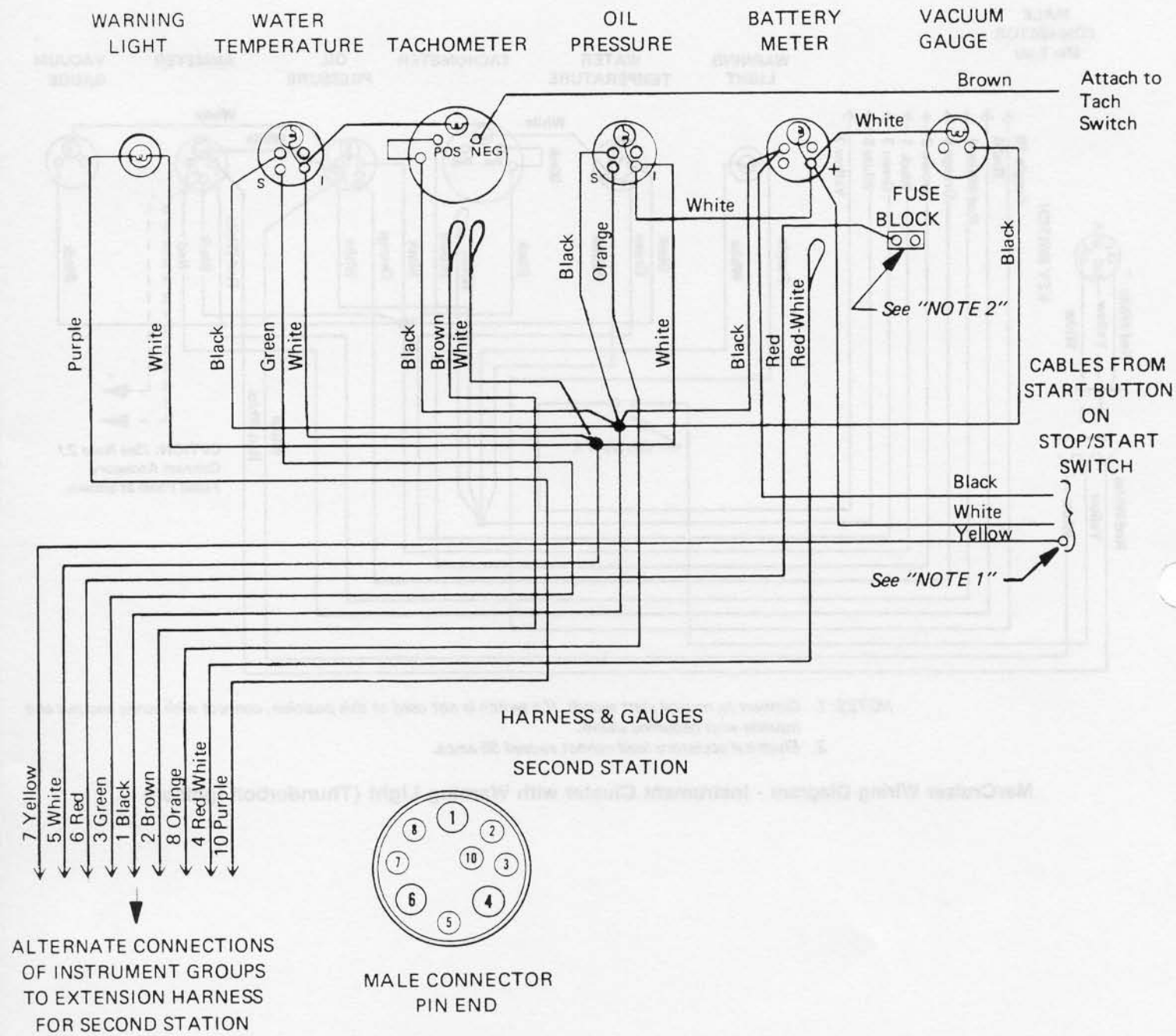
MerCruiser Wiring Diagram - Instrument Cluster with Warning Light (Standard Ignition)



NOTES: 1. Connect to neutral start switch. If a switch is not used at this position, connect with screw and nut and insulate with neoprene sleeve.

2. Electrical accessory load cannot exceed 35 amps.

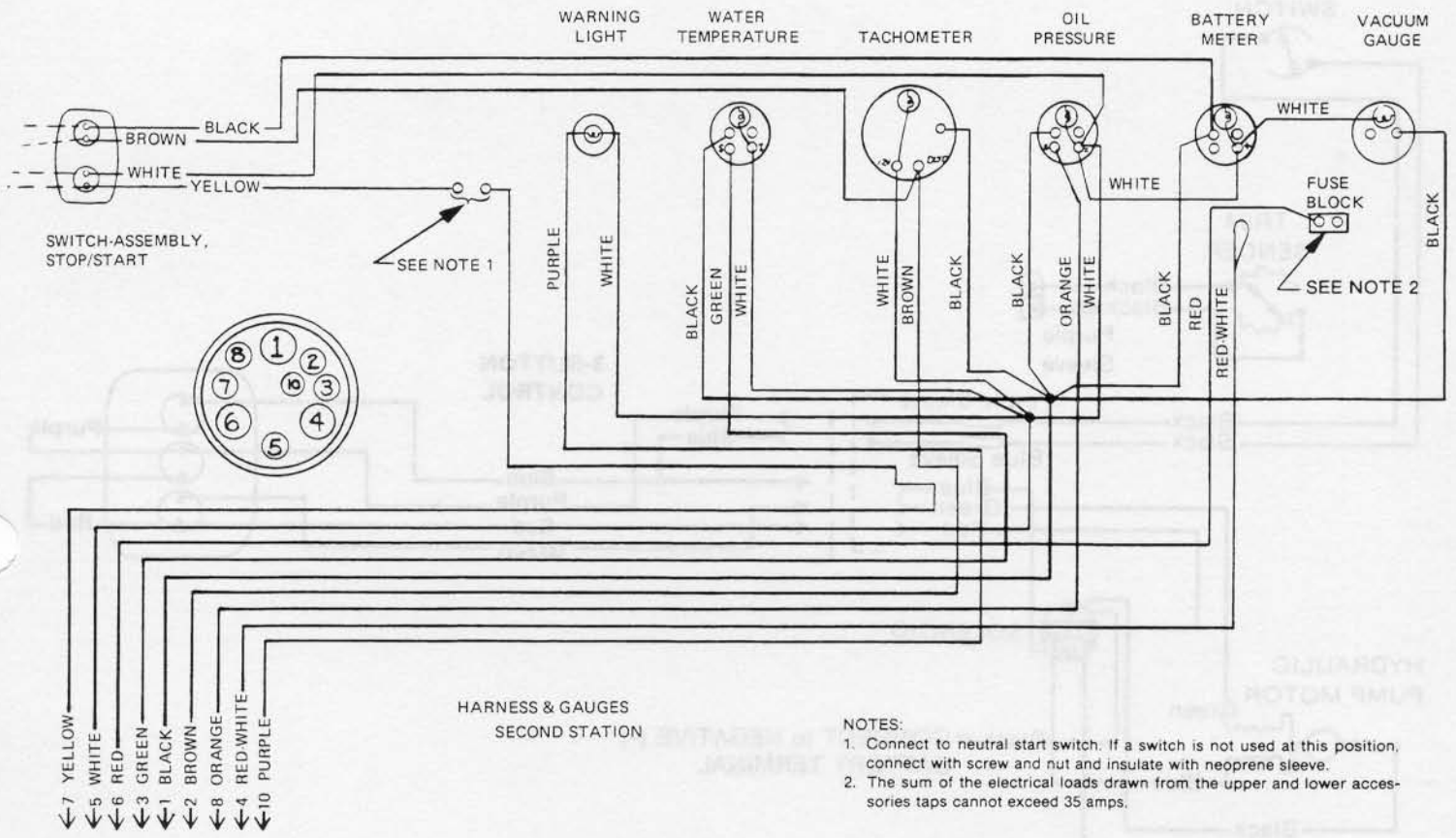
MerCruiser Wiring Diagram - Instrument Cluster with Warning Light (Thunderbolt Ignition)



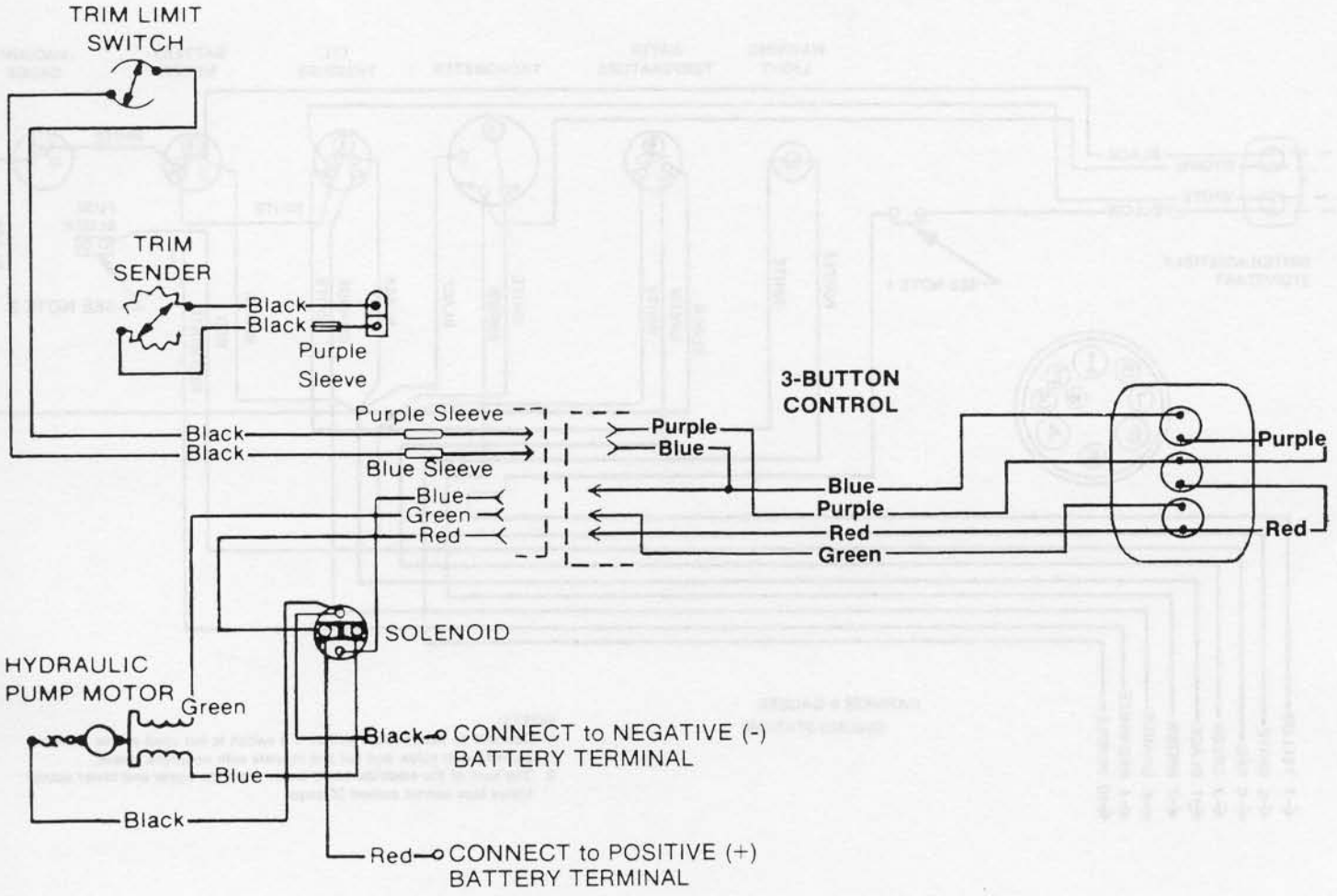
NOTES:

1. *Connect to Neutral Safety Switch. If a Switch Is Not Used at This Position, Connect with Screw and Nut; Insulate with Neoprene Sleeve.*
2. *The Sum of the Electrical Loads (Drawn from the Upper and Lower Accessories Taps) Cannot Exceed 35 Amps.*

MerCruiser Wiring Diagram - Instrument Cluster Second Station (Thunderbolt Ignition)

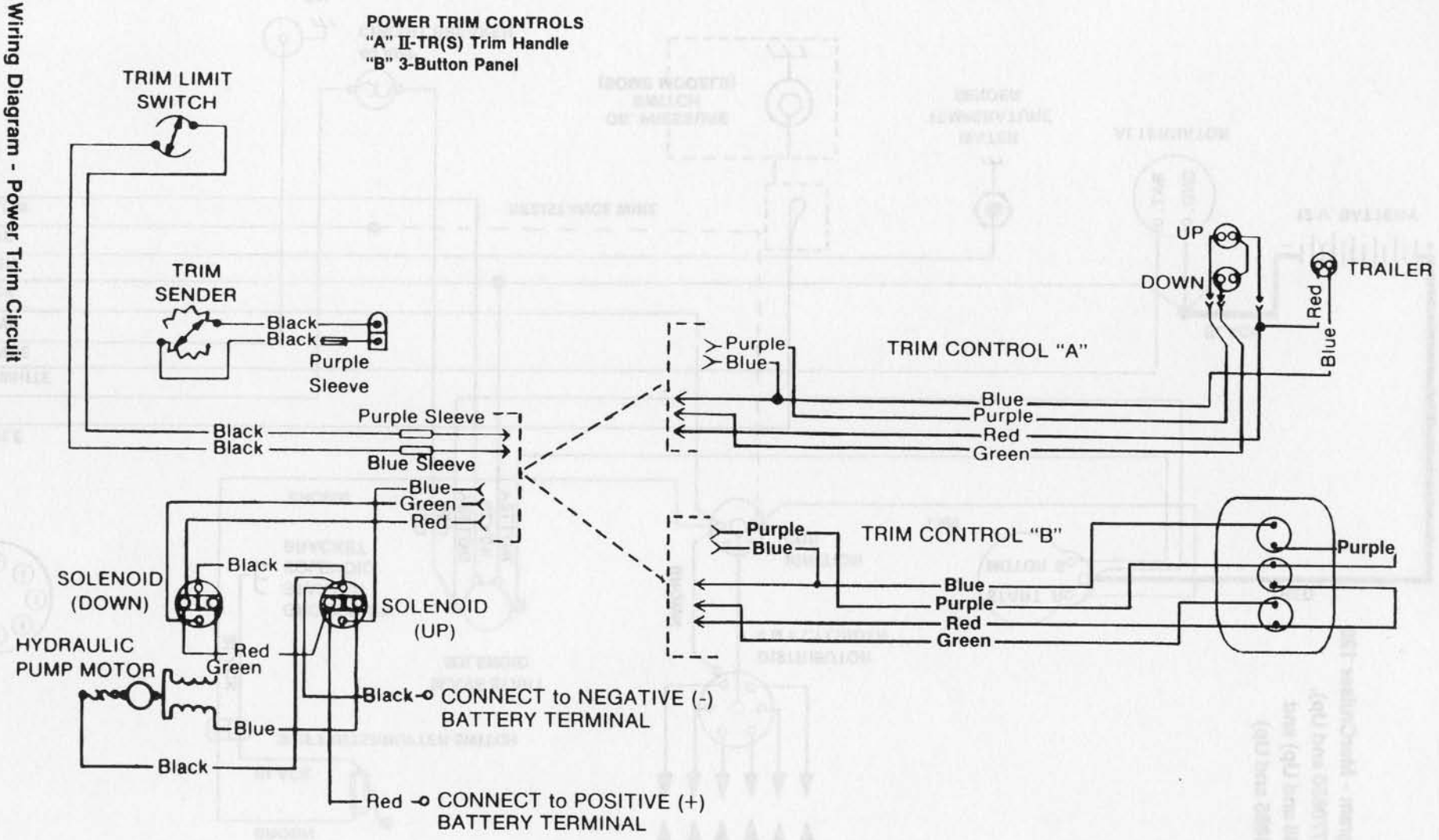


MerCruiser Wiring Diagram - Instrument Cluster Second Station (Standard Ignition)

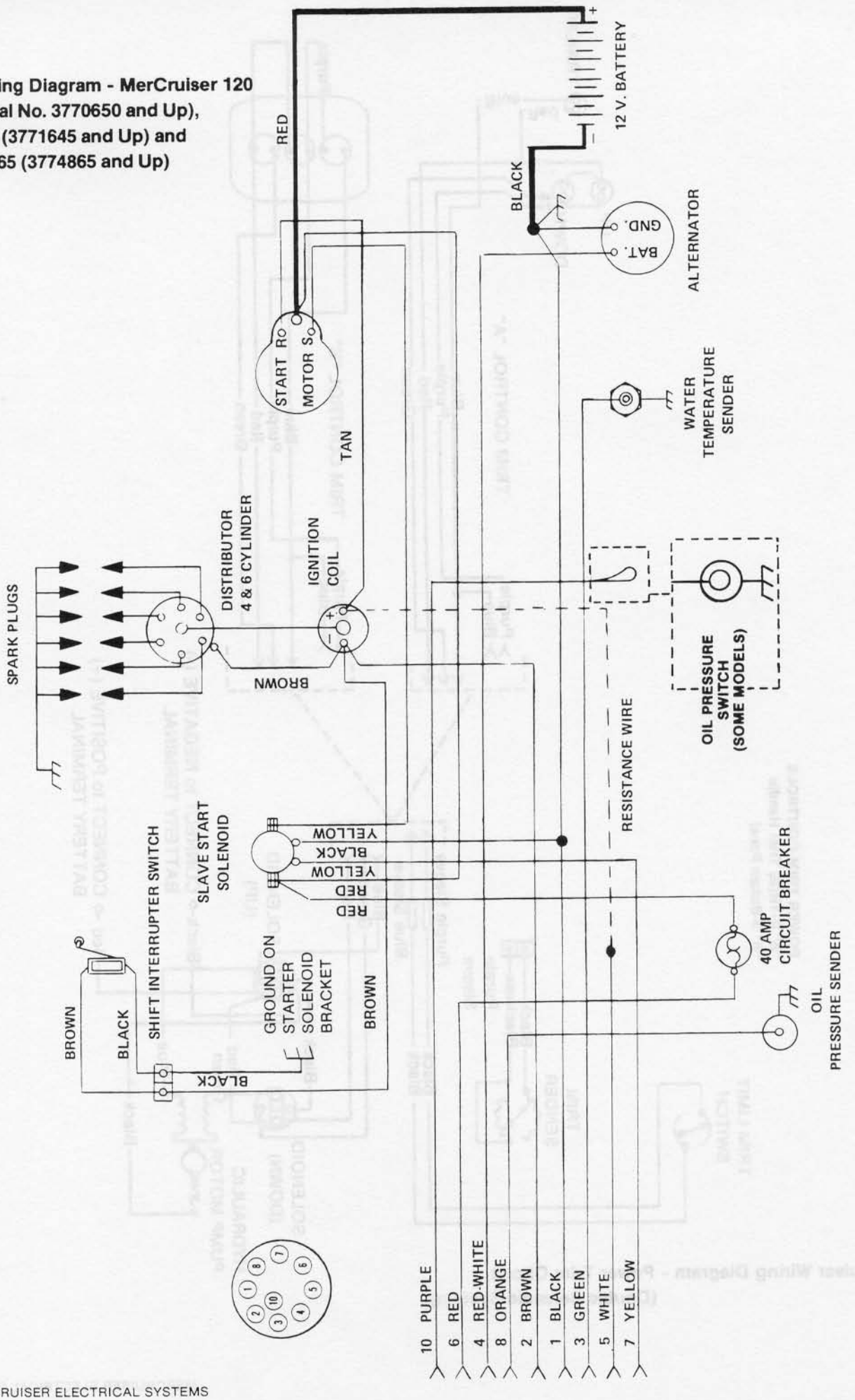


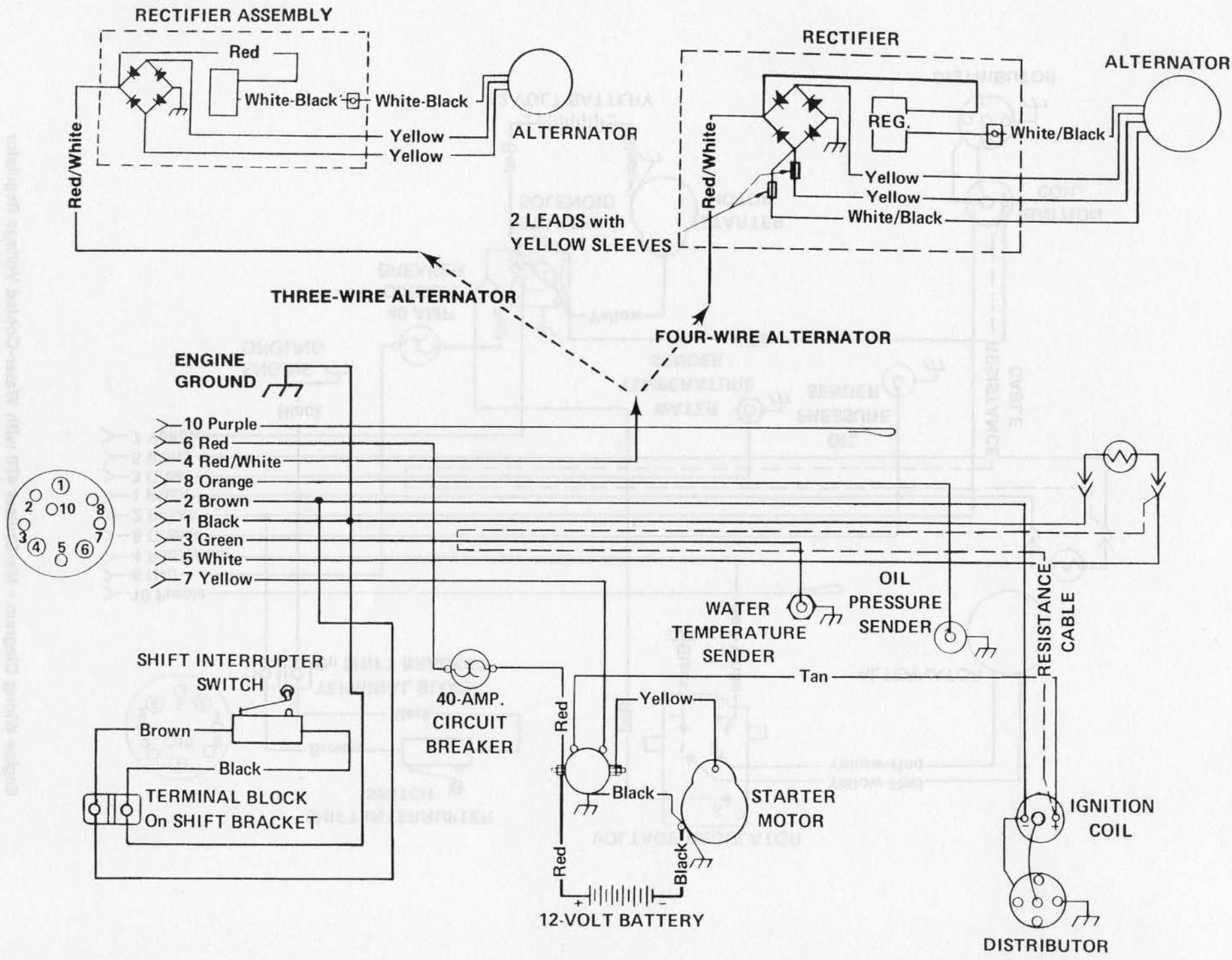
MerCruiser Wiring Diagram - Power Trim Circuit (Single Solenoid System)

MerCruiser Wiring Diagram - Power Trim Circuit (Double Solenoid System)

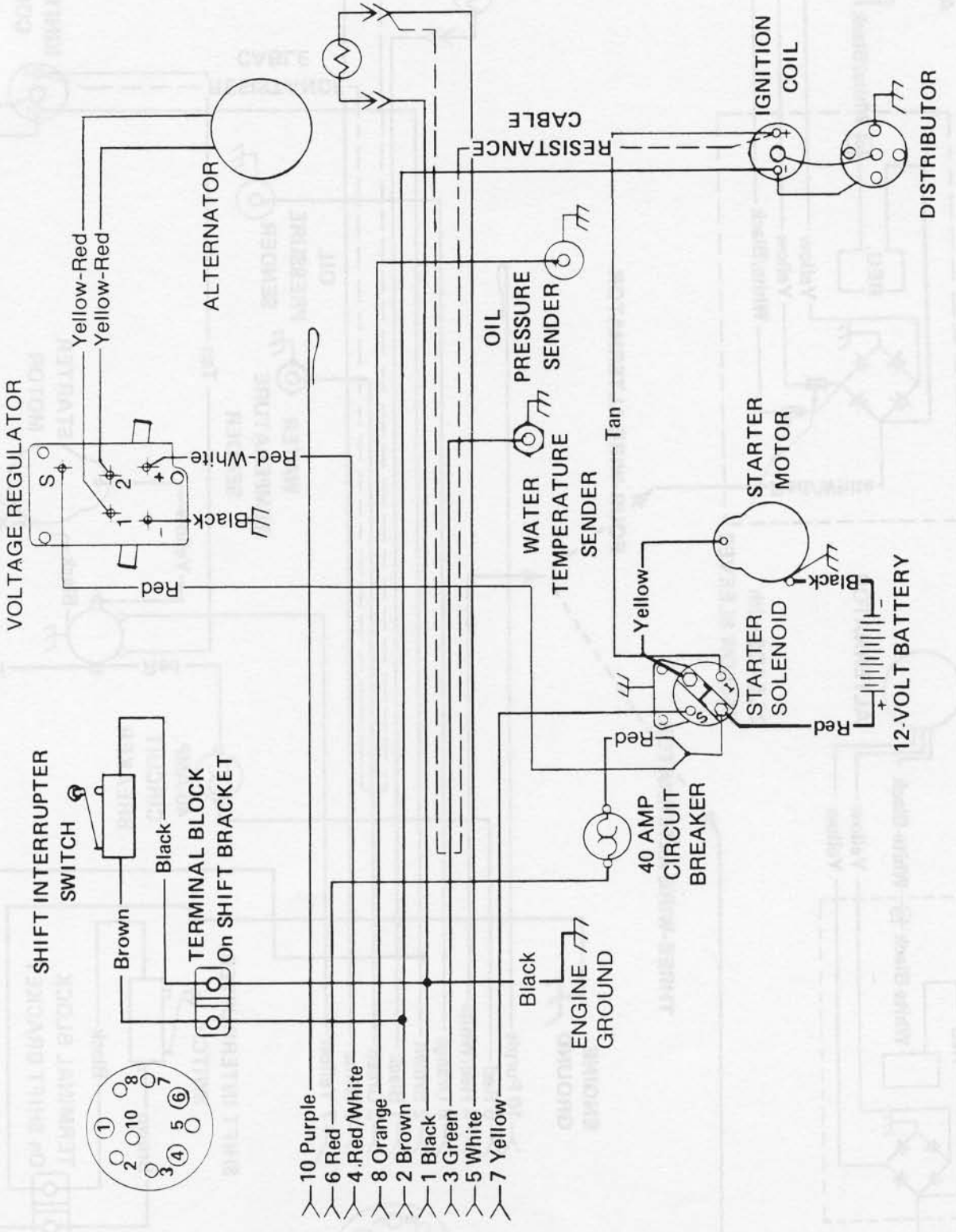


Engine Wiring Diagram - MerCruiser 120 (Serial No. 3770650 and Up), 140 (3771645 and Up) and 165 (3774865 and Up)

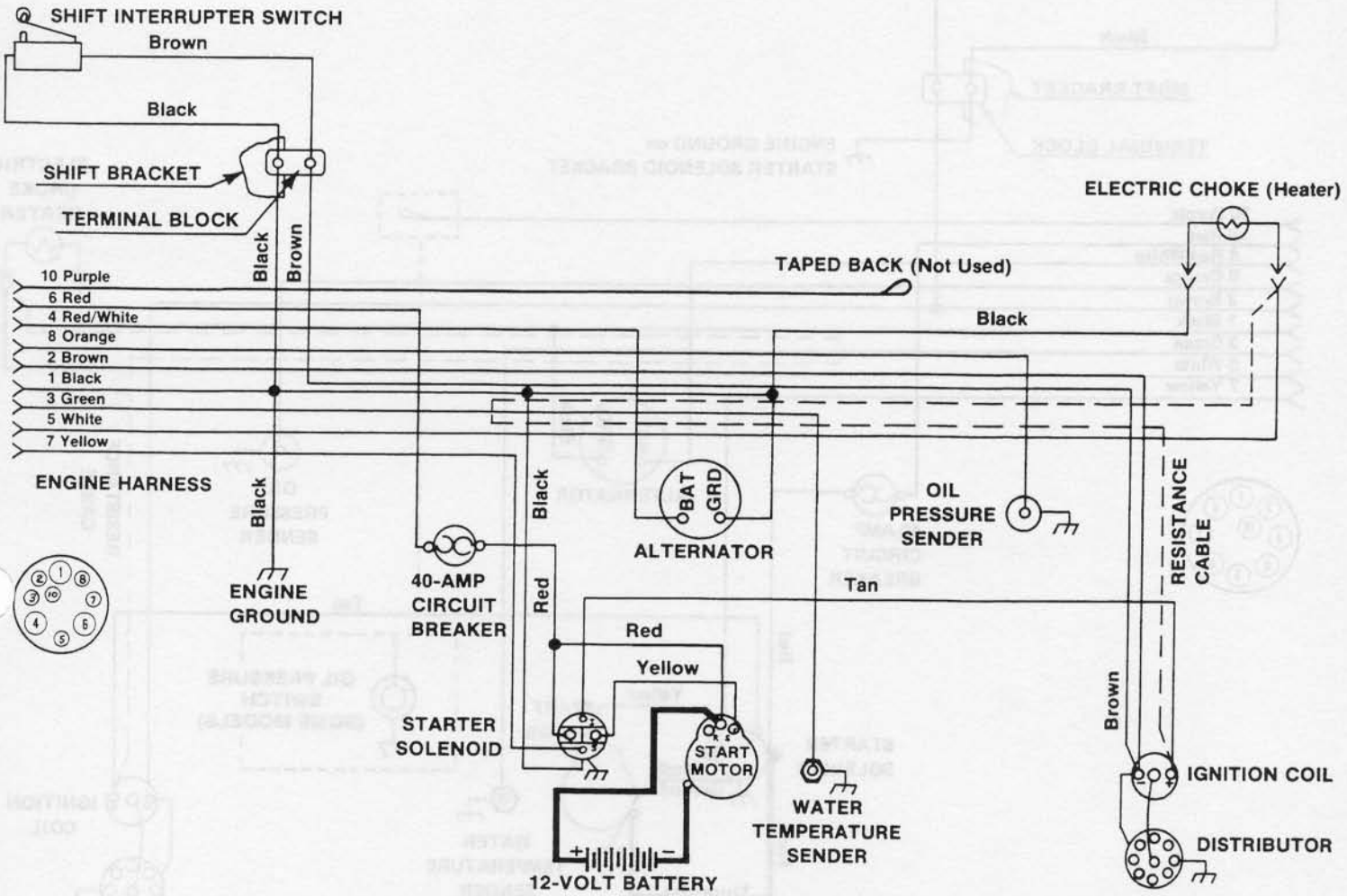




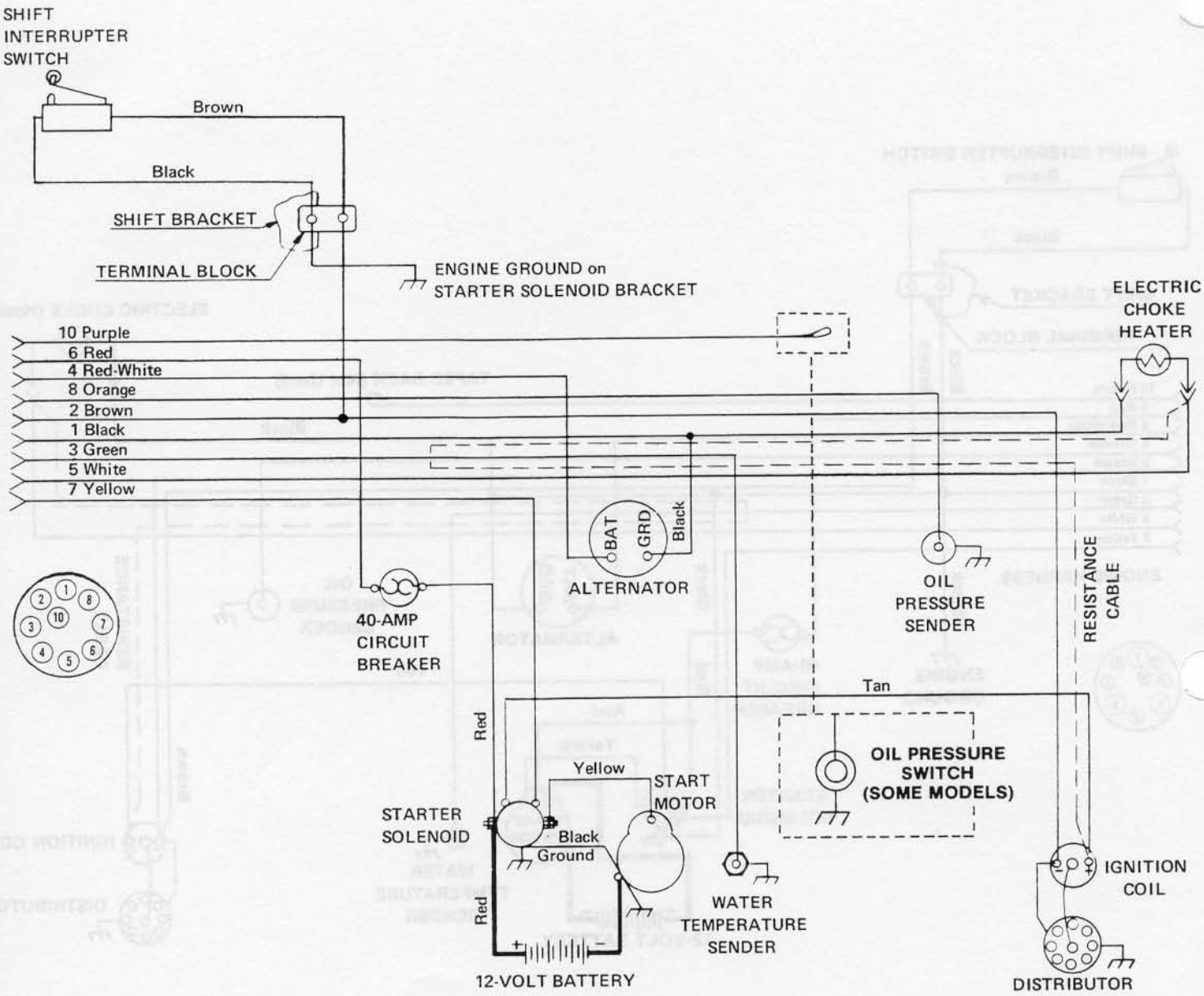
Engine Wiring Diagram - MerCruiser 470 with Air-Cooled Voltage Regulator



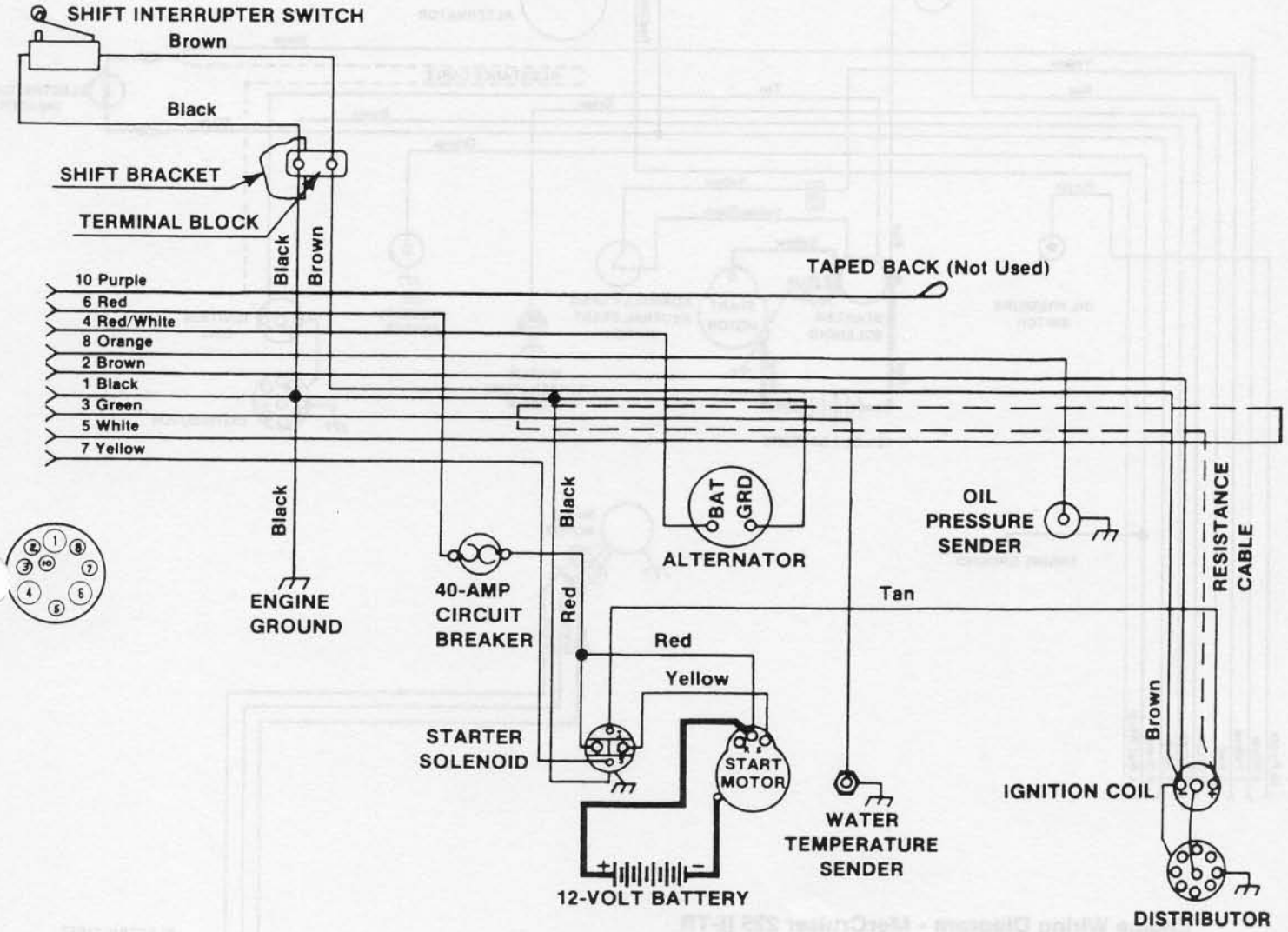
Engine Wiring Diagram - MerCruiser 470 with Water-Cooled Voltage Regulator



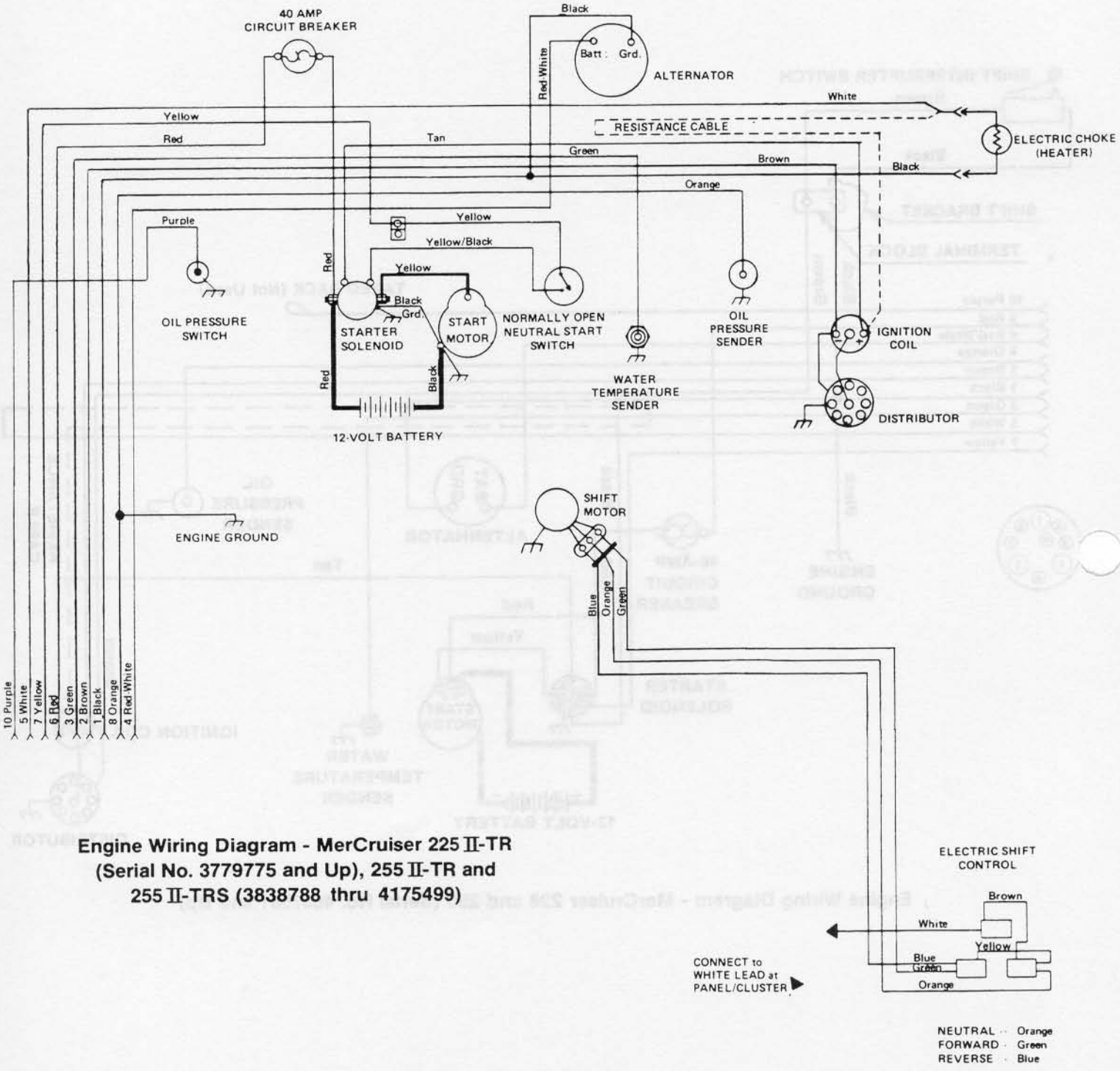
Engine Wiring Diagram - MerCruiser 898



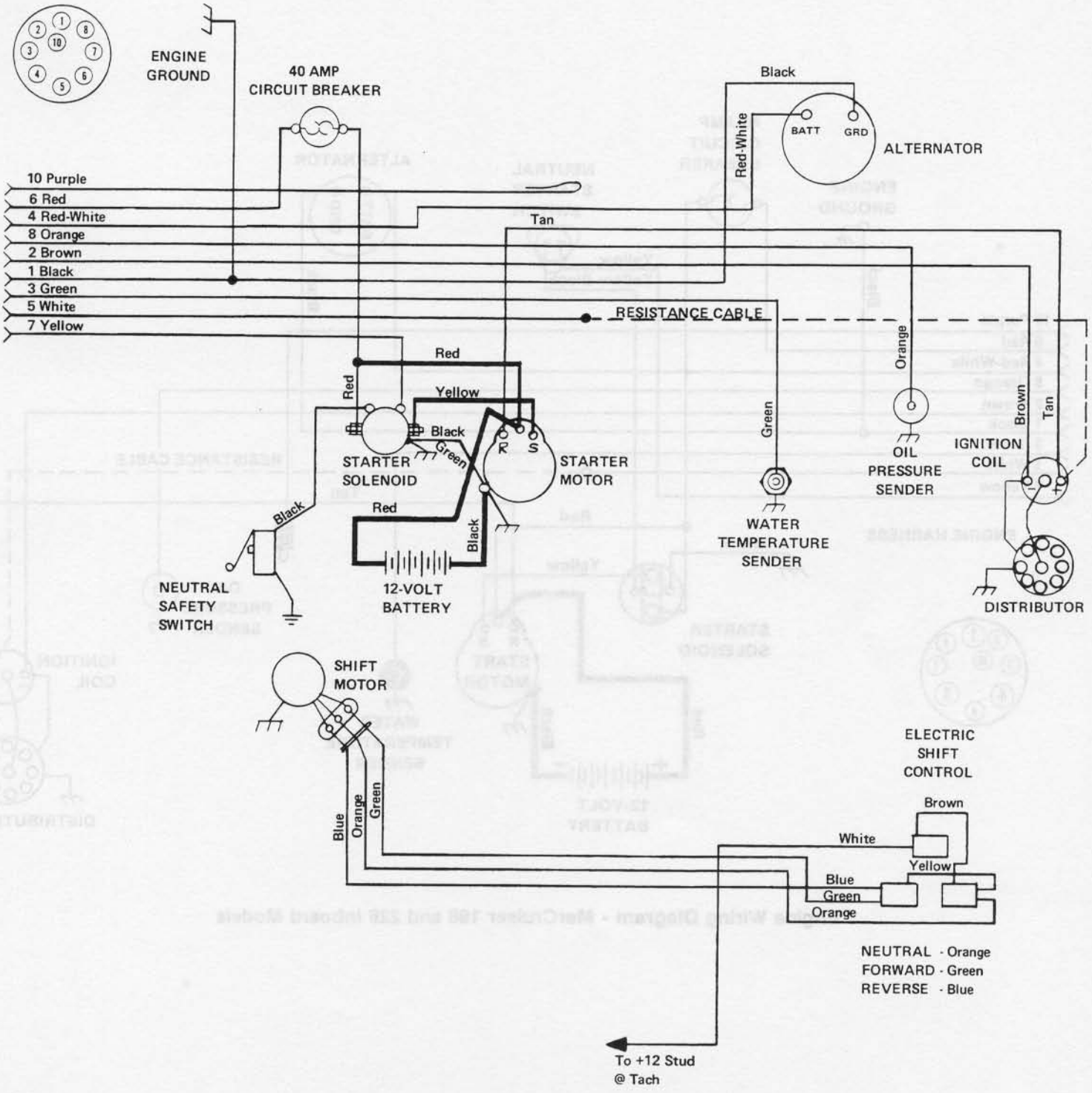
Engine Wiring Diagram - MerCruiser 888 (Serial No. 3777490 and Up), 225-S (3836688 and Up) and 233



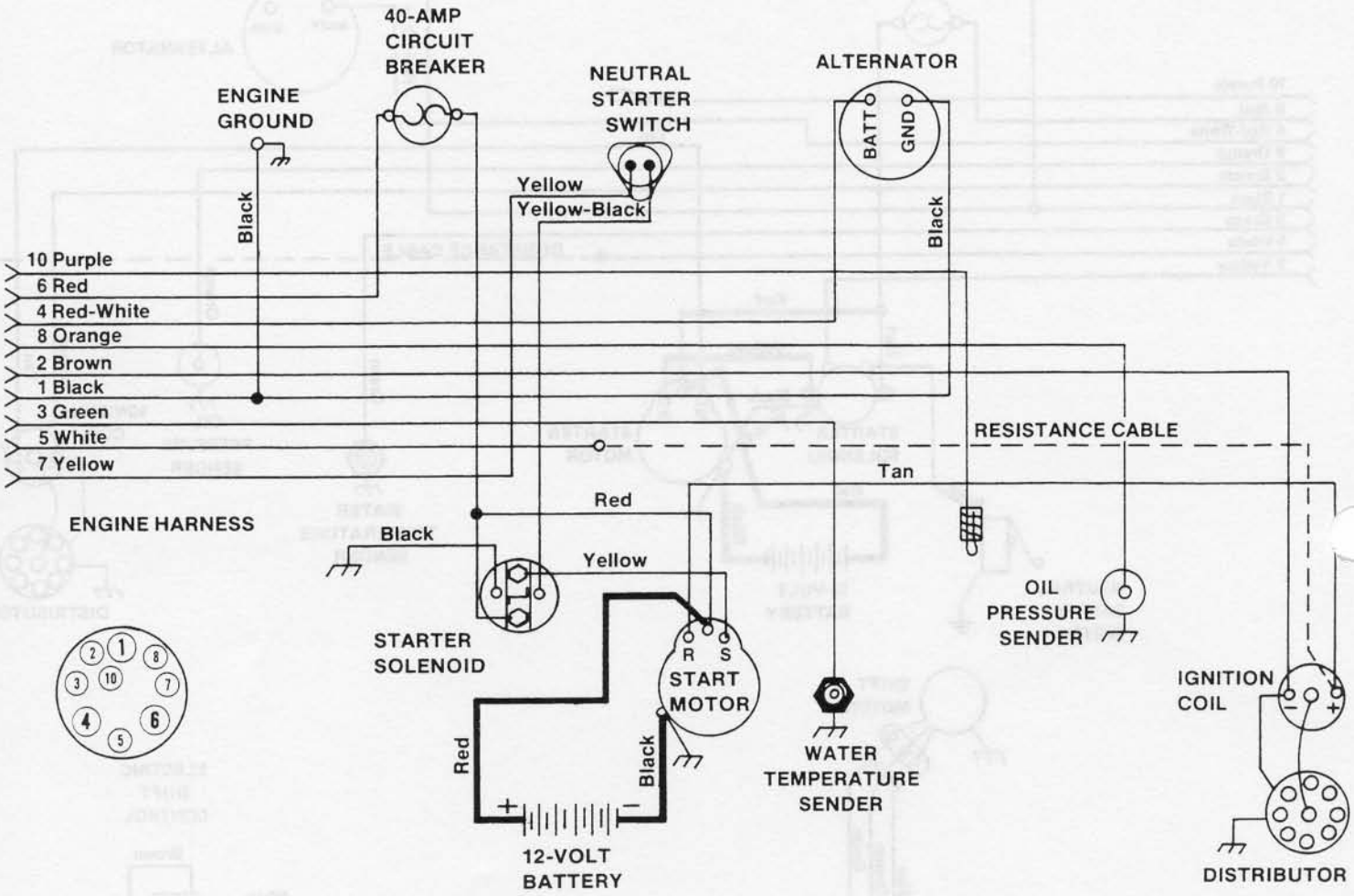
Engine Wiring Diagram - MerCruiser 228 and 250 (Serial No. 4657551 and Up)



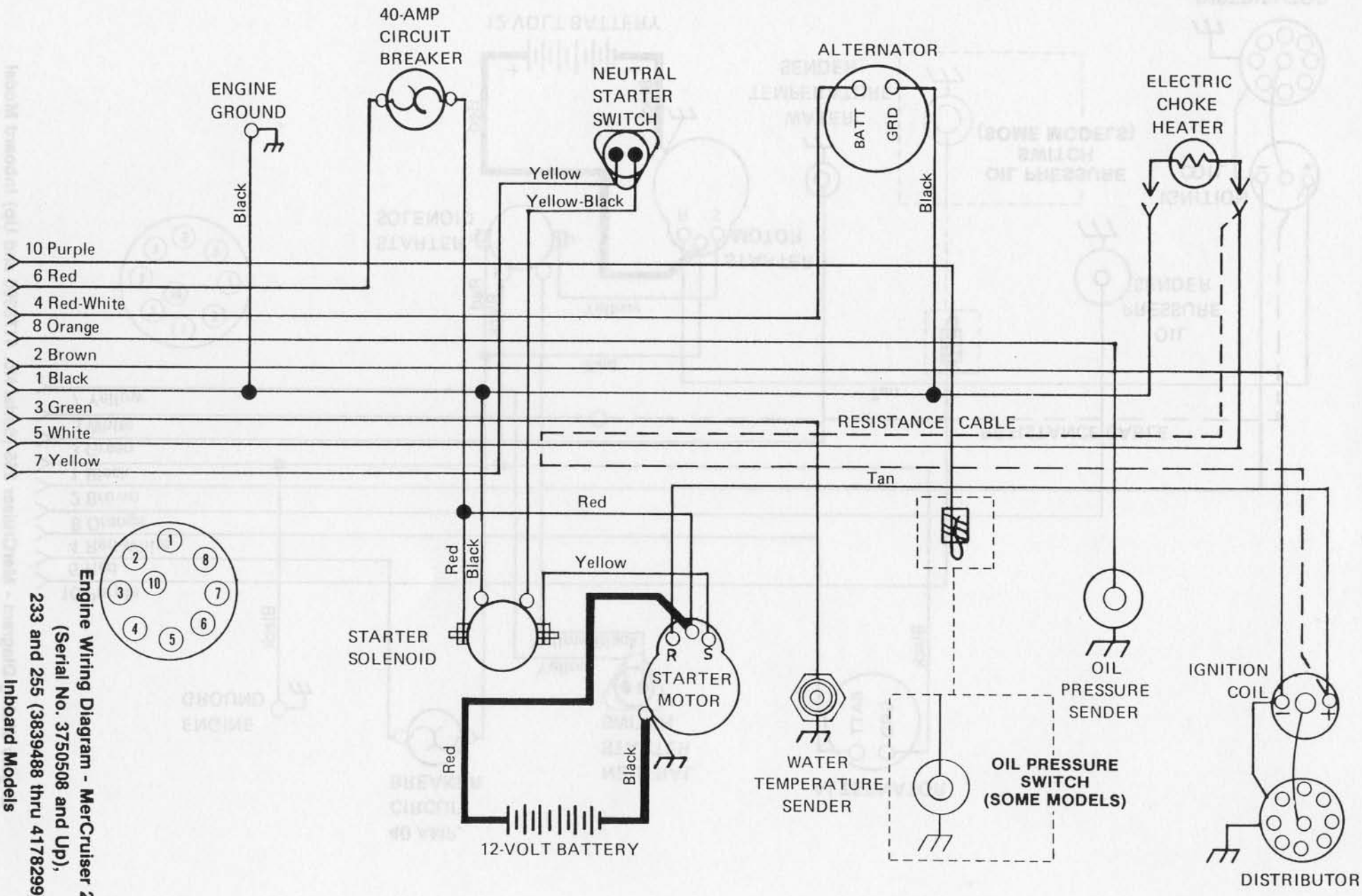
Engine Wiring Diagram - MerCruiser 225 II-TR (Serial No. 3779775 and Up), 255 II-TR and 255 II-TRS (3838788 thru 4175499)



Engine Wiring Diagram - MerCruiser 228-TR, 255-TR (Serial No. 4175500 and Up), 280-TRS, 330-TR and 330-TRS

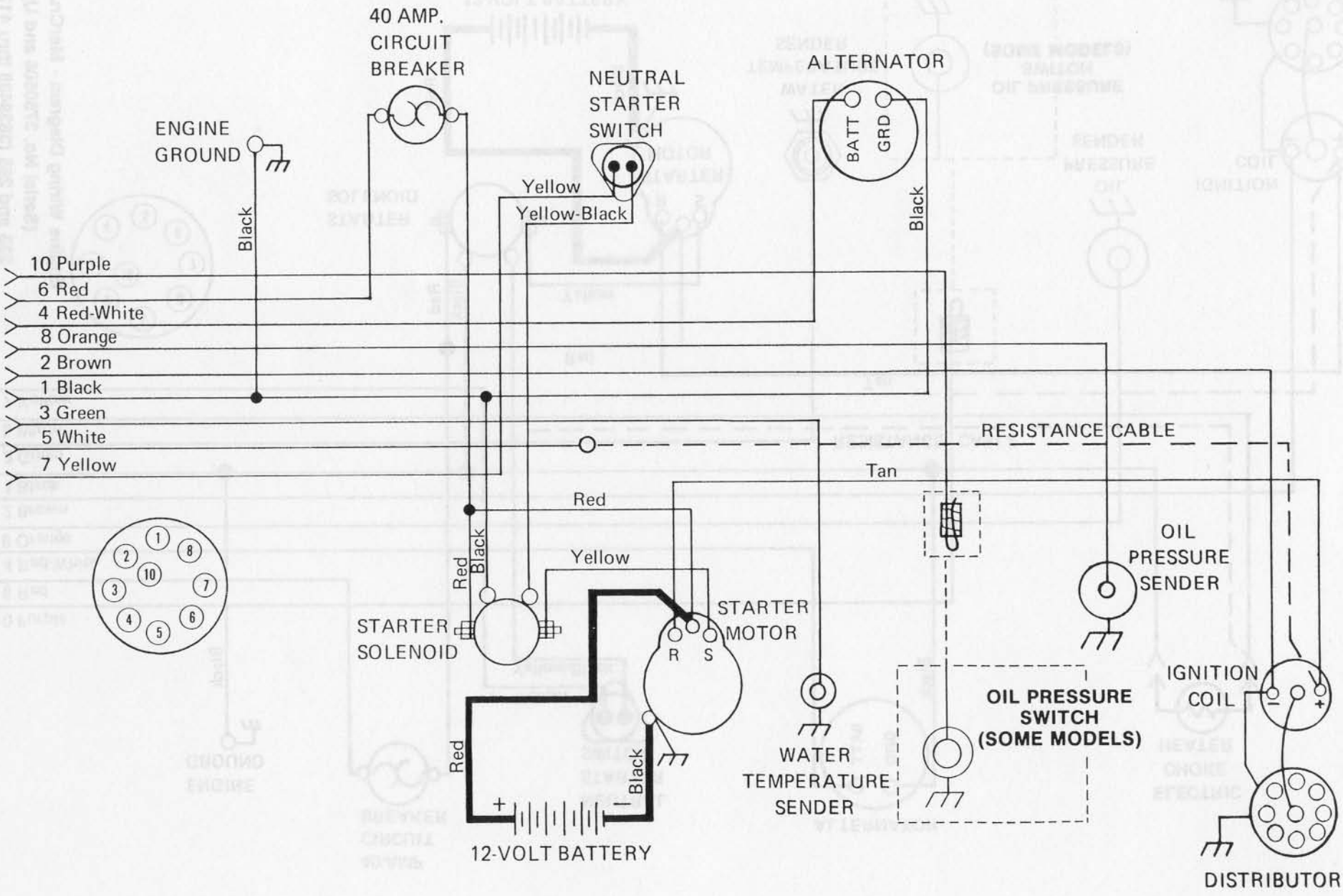


Engine Wiring Diagram - MerCruiser 198 and 228 Inboard Models

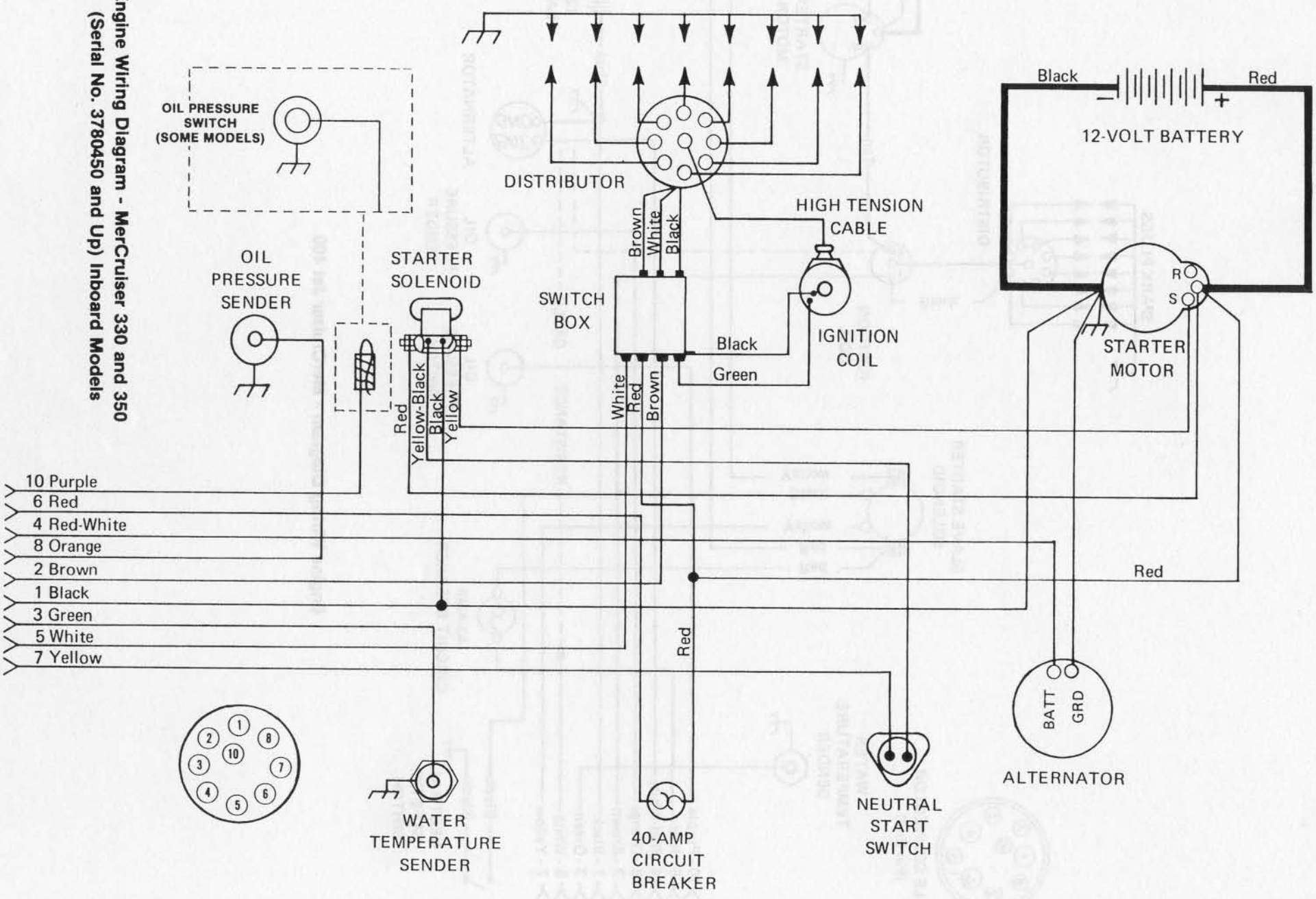


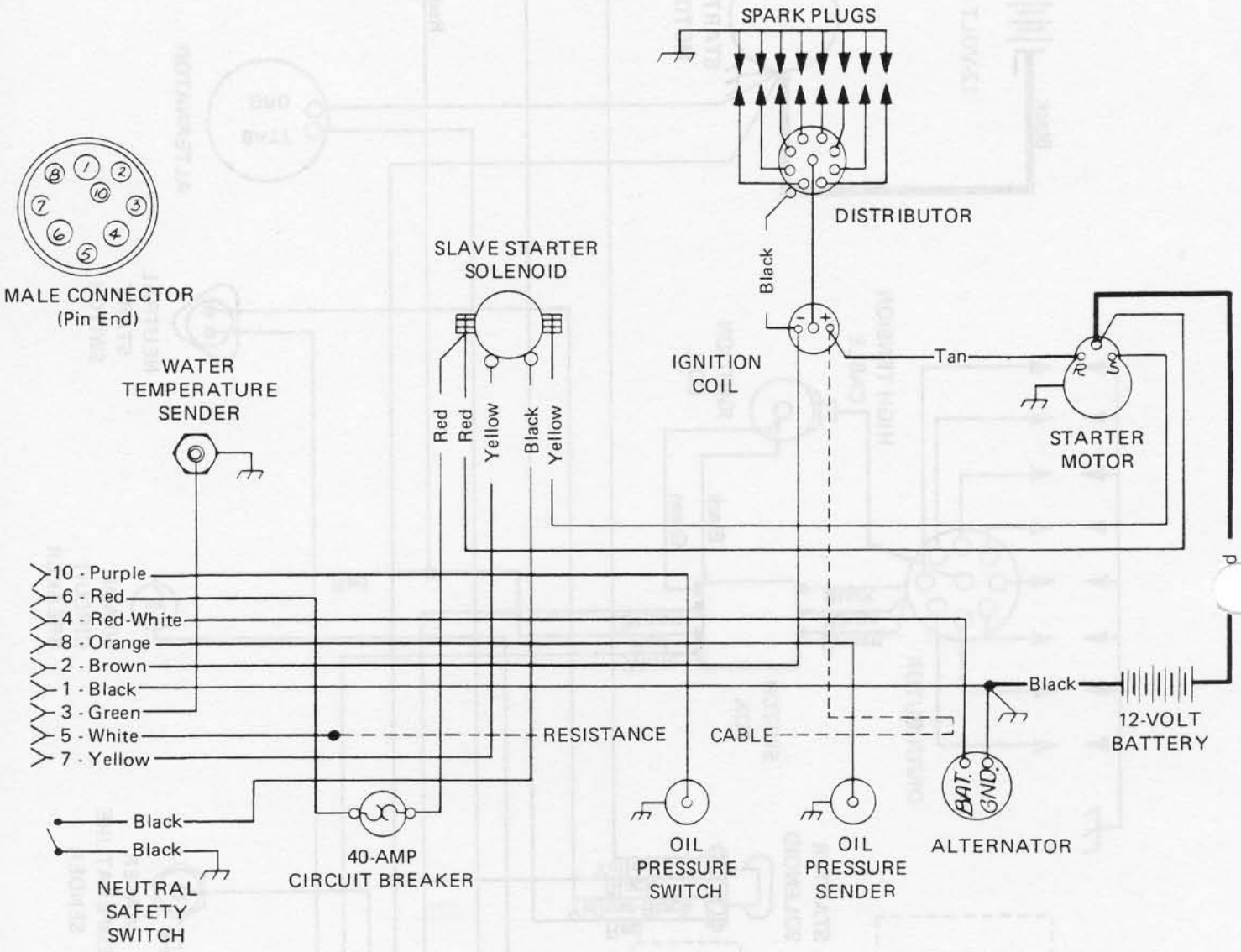
Engine Wiring Diagram - MerCruiser 225 (Serial No. 375508 and Up), 233 and 255 (3839488 thru 4178299) Inboard Models

Engine Wiring Diagram - MerCruiser 255 (Serial No. 4178300 and Up) Inboard Model



Engine Wiring Diagram - MerCruiser 330 and 350 (Serial No. 3780450 and Up) Inboard Models

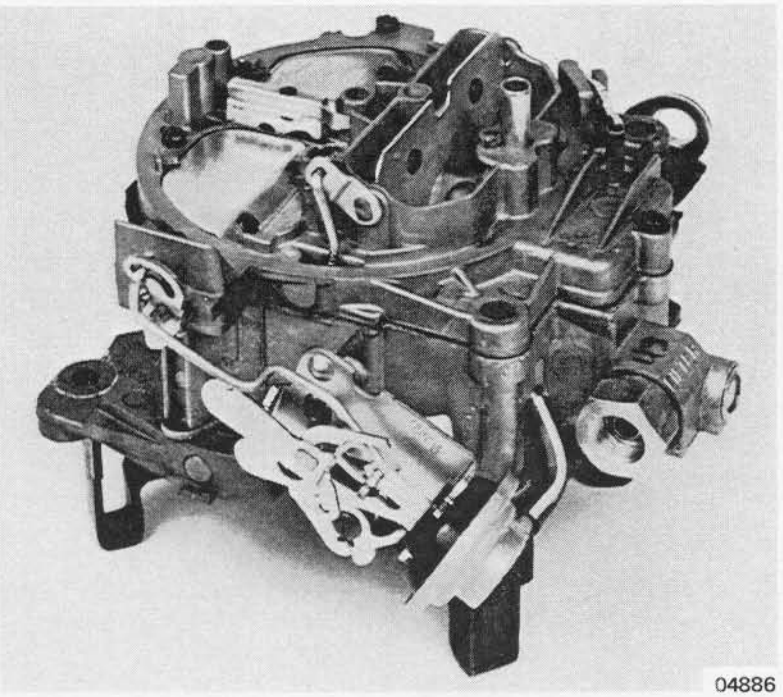




Engine Wiring Diagram - MerCruiser Jet 400

FUEL SYSTEM

MERCRUISER Section 4



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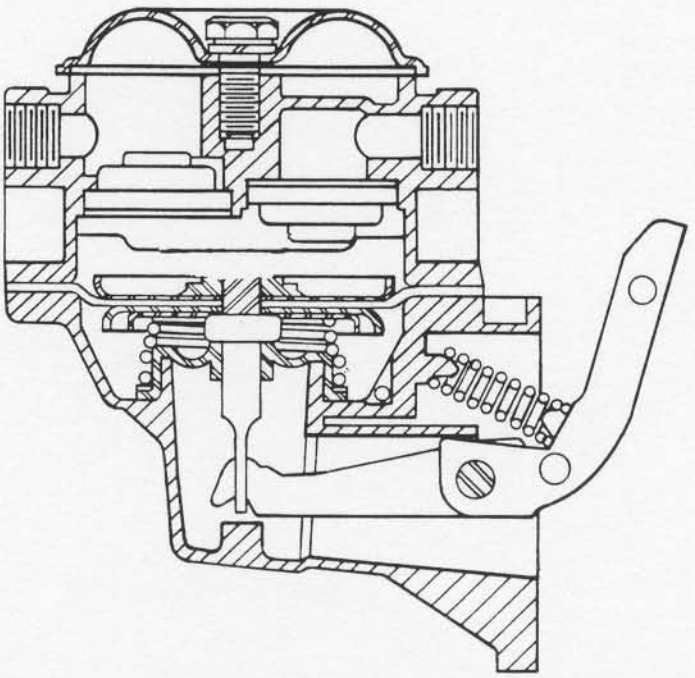
SECTION 4 - FUEL SYSTEMS

MERCRUISER

PART A - FUEL PUMPS



MERCURY MARINE

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PUMP VOLUME

1. Disconnect fuel line at carburetor and direct line into a container indicating pint level.
2. Start engine and run at idle, using fuel in carburetor bowl to run engine.
3. Measure time required to deliver one pint of fuel, then shut off engine. At idle, pump should deliver one pint of fuel in 30 to 45 seconds.
   a. If no gasoline or only a small amount flows from open end of line, fuel line is clogged or pump is defective. Before removing pump, remove fuel tank filler cap, disconnect both inlet and outlet lines from pump and blow thru lines with air hose to clear passage and eliminate possible clogged fuel filter in fuel tank. Reconnect lines to pump and retest flow.
   b. If pump volume is within limits, proceed with "Pump Pressure Test", following. If pump volume is not within limits, repair or replace fuel pump.

WARNING: Check all connections for fuel leaks.

PUMP PRESSURE TEST

1. Disconnect fuel line at output side of fuel pump and attach fuel pump pressure gauge to fuel line.
2. Start engine and run at idle. Observe reading on gauge.
3. If pump is operating properly, pressure will be 5¼ to 6½ PSI for V-8 engine, 3½ to 4½ PSI for 4 and 6-cylinder engines, and will remain constant at speeds between idle and 1000 RPM. If pressure is too low or too high, or varies at different speeds, remove pump for repair. If fuel pump pressure checks out correctly after a high speed problem, overhaul carburetor.
4. Remove gauge and reconnect fuel line. Inspect fuel line for kinks and sharp bends and check all connections for leaks.

TROUBLESHOOTING

Refer to Section 10, "Troubleshooting".

CARTER FUEL PUMP (Part No. B-47585)

REMOVAL

WARNING: Before servicing the fuel system, always disconnect the negative (-) battery terminal. This will prevent accidental shorting which may ignite fuel that is spilled when fuel lines are disconnected.

1. Disconnect fuel inlet and outlet lines at fuel pump.
2. Remove 2 fuel pump mounting bolts and lockwashers, pump and gasket.

NOTE: After removal of pump from engine and before disassembly is started, plug all openings and thoroughly wash exterior of pump with cleaning solvent to remove all dirt and grease.

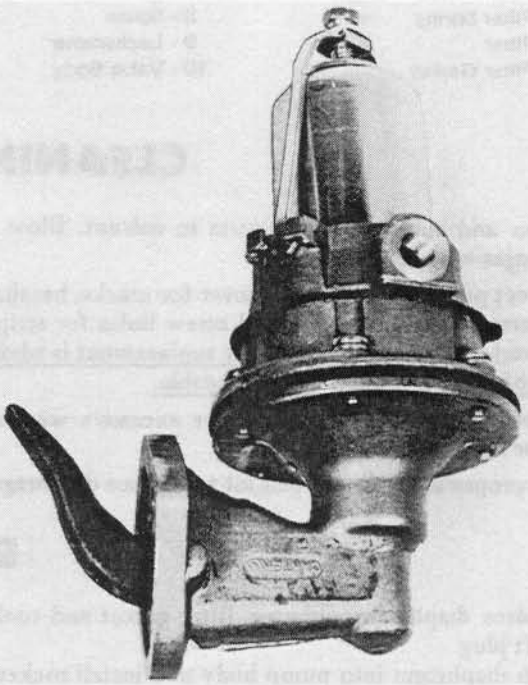

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Figure 1. Carter Fuel Pump

DISASSEMBLY

1. Mark edges of fuel cover and body flange with file. Parts then may be reassembled in same relative position.
2. Loosen screw and remove filter holder, filter and gasket.
3. Remove 6 phillips head screws and pump body.
4. Remove 2 screws and lockwasher and separate lower housing, pulsator, diaphragm and valve housing.
5. Remove spring, rocker arm shaft plug, safety pin, rocker arm shaft and rocker arm from main body.
6. Remove diaphragm seal assembly.

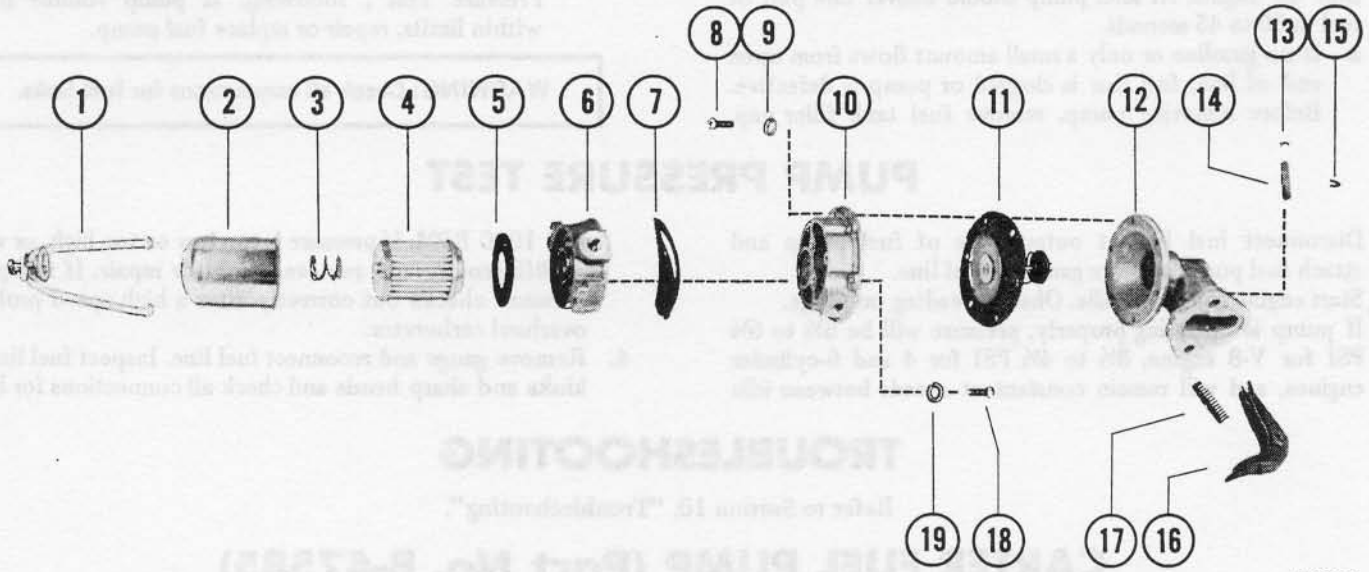

Figure 2. Carter Fuel Pump, Exploded View

1 - Filter Cover Retainer
2 - Filter Cover
3 - Filter Spring
4 - Filter
5 - Filter Gasket
6 - Pulsator Housing
7 - Pulsator
8 - Screw
9 - Lockwasher
10 - Valve Body
11 - Diaphragm
12 - Pump Body
13 - Rocker Arm Pin Plug
14 - Rocker Arm Pin
15 - Rocker Arm Retainer
16 - Rocker Arm
17 - Rocker Arm Spring
18 - Screw
19 - Lockwasher

CLEANING and INSPECTION

1. Clean and rinse all metal parts in solvent. Blow out all passages with compressed air.
2. Inspect pump body and fuel cover for cracks, breakage and distorted flanges. Examine all screw holes for stripped or crossed threads. Pump assembly replacement is advisable if one of main castings is not serviceable.
3. Inspect rocker arm and link for excessive wear and for loose hinge pin.
4. Use proper diaphragm repair kit to replace diaphragm.
5. Replace rocker arm spring and diaphragm springs as removed. Old springs may be distorted, weak or corroded.
6. Check condition of valves by pushing each valve off its seat with a thin rod or pencil. Insert hooked wire thru inlet opening in fuel cover to move fuel inlet valve off its seat. If a valve sticks to its seat, if it moves off its seat and does not rebound or, if cage is damaged, complete valve must be replaced. To remove valves, clear staked metal (with a sharp chisel, file or suitable scraper) and pull valve out with a hook-shaped tool.

REASSEMBLY

1. Replace diaphragm, pulsator, filter gasket and rocker arm shaft plug.
2. Push diaphragm into pump body and install rocker arm so that fork catches diaphragm.
3. Install rocker arm shaft, safety pin and rocker arm shaft plug.
4. Attach valve housing to lower housing with 2 screws.
5. Assemble pump bodies with 6 phillips head screws, making sure that file marks line up.

CAUTION: Diaphragm must be flexed to its full stroke while tightening cover screws, or pump diaphragm protector will not be properly centered, thereby rubbing on the pump body casting and wearing diaphragm.

6. Reassemble filter to pump body, using new filter.

INSTALLATION

1. Install fuel pump gasket and fuel pump.
2. Connect fuel lines to pump.
3. Start engine and check for leaks.

DUAL DIAPHRAGM FUEL PUMP

DESCRIPTION

These pumps have 2 diaphragms (separated by a metal spacer) and a sight gauge attached.

Dual diaphragm construction has 3 important safety features.

1. If main diaphragm fails, pump continues to function with second diaphragm.
2. No gasoline can leak outward from pump. It can leak only into space between diaphragms.
3. Gasoline in sight gauge exposes defective pump.

Possibility of diaphragms failing simultaneously is remote, since they are composed of different materials and are shaped differently.

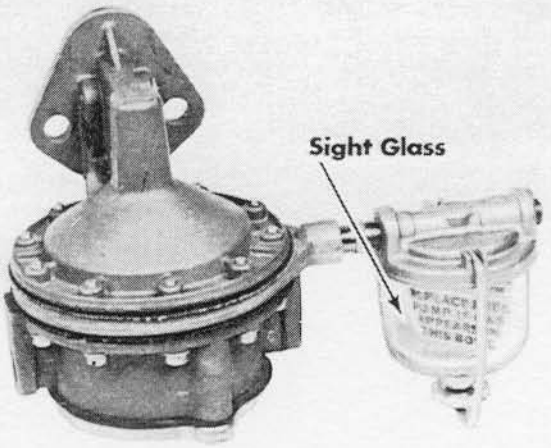

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Figure 1. Dual Diaphragm Fuel Pump

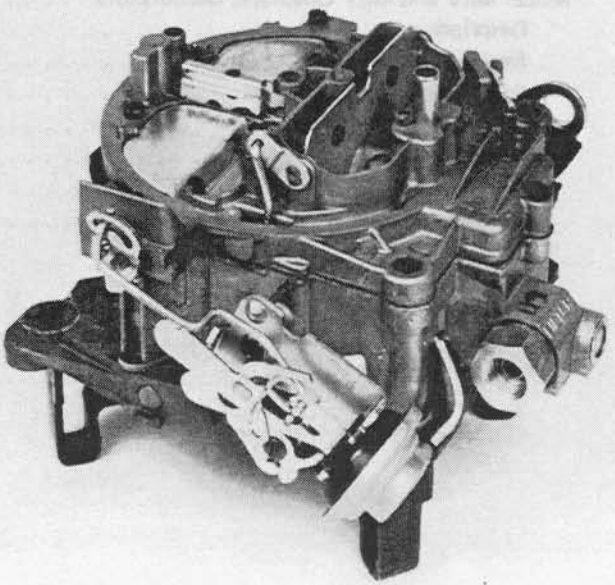
INSPECTION and REPLACEMENT

Dual diaphragm pump is not repairable and, therefore, must be replaced if defective. Inspect sight glass for fuel. If fuel is present, replace fuel pump.

SECTION 4 - FUEL SYSTEMS

MERCRUISER

PART B - CARBURETORS



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MERCURY MARINE

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MAIN METERING STANDARD JET SIZES

Do not identify main metering jets by the orifice size which is stamped on front of jet. It is possible to have 3 different jets with the same size orifice, as jets are available with 3 different approach angles. Figures, shown below, illustrate the approach angles that a jet may have. All 3 could have the same size orifice, although each one will allow a different amount of fuel to flow thru the carburetor. When ordering replacement jets, order by part number and not by orifice size.

90° Approach Angle

Partial 60° Approach Angle

Full 60° Approach Angle

HIGH ALTITUDE PERFORMANCE - MERCRUISER ENGINES

High altitude performance tests have shown that very little performance improvement is realized by increased spark advance or carburetor recalibration. On the contrary, repropping the unit to run at its rated RPM has shown a significant increase in performance. Based on this testing, our general recommendation should be to "reprop the unit to its rated RPM in order to obtain maximum performance".

Any recommendation, other than changing props, to obtain rated RPM should be considered a special case and referred to the factory branch or area distributor for specific jet sizes and spark timing settings. These recommendations should not be made until the customer is fully aware of the following points:

1. Operating an engine with the above changes at lower elevation will cause engine failure.
2. Making the above changes (leaner jets and advanced spark timing) will result in increased fuel economy, but will not have a significant effect on performance.

PRECAUTIONS

After installation of carburetor, manually operate throttle for full open and close position to check for a binding or sticking condition of the throttle linkage. This is especially important in applications that include dashpots and other throttle actuated mechanisms. It may be necessary to remove and replace these mechanisms and carburetor throttle linkage parts on carburetor. Failure to follow these procedures may result in uncontrolled engine speed.

TROUBLESHOOTING

Refer to Section 10, "Troubleshooting".

MODEL 2GC and 2GV CARBURETORS

DESCRIPTION

The 2GC is a 2-bore carburetor with automatic choke. The major portion of calibrated metering parts are contained in the venturi cluster (located in float bowl) and may be serviced readily by removing air horn assembly. Idle tubes and main discharge nozzles are pressed into venturi clusters and need not be serviced separately. Pump jets are part of venturi cluster also. Power restrictions are pressed into fuel bowl at factory, thereby making replacement unnecessary.

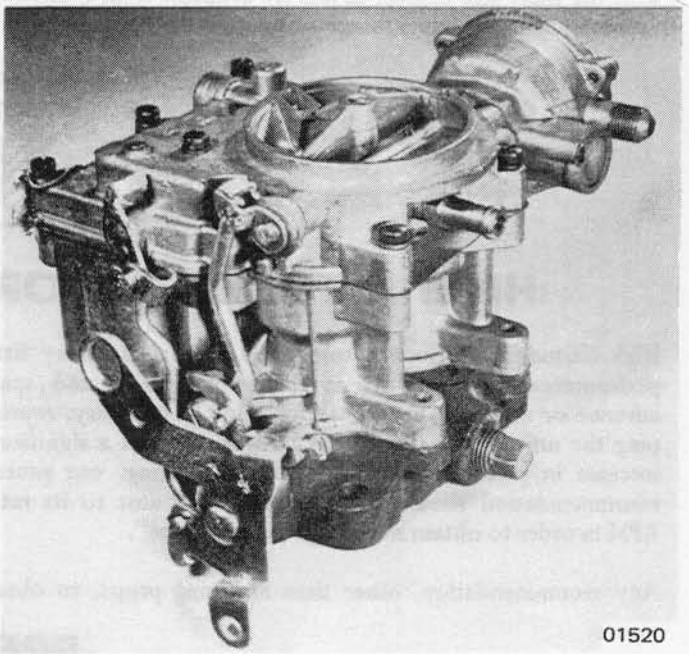

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Figure 1. 2GC Carburetor

Legend for Figure 2

1 - Air Horn
2 - Power Piston Assembly (6-Cyl. and 140)
3 - Gasket
4 - Screw
5 - Screw
6 - Lockwasher
7 - Nut
7A - Filter
7B - Spring
8 - Gasket
9 - Float Assembly
10 - Pin, hinge
11 - Inlet Needle and Seat Assembly
12 - Gasket
13 - Strainer
14 - Float Bowl Assembly
15 - Venturi Cluster Assembly
16 - Gasket
17 - Screw
18 - Gasket
19 - Screw
20 - Lockwasher
21 - Guide
22 - Spring
23 - Ball
24 - Power Valve Assembly (6-Cyl. and 140)
25 - Gasket (6-Cyl. and 140)
26 - Jet
27 - Strainer
28 - Lever, pump
29 - Screw
30 - Pump Shaft and Lever Assembly
31 - Rod, pump
32 - Clip, retainer
33 - Pump Assembly
34 - Clip, retainer
35 - Spring, pump return
36 - Ball, check
37 - Gasket
38 - Throttle Body Assembly
39 - Idle Adjusting Needle
40 - Spring
41 - Idle Stop Screw
42 - Clip
43 - Gasket
44 - Screw
45 - Lockwasher
46 - Cam, fast idle
47 - Screw
48 - Rod, choke
49 - Choke Lever and Collar Assembly
50 - Choke Shaft Assembly
51 - Valve, choke
52 - Screw
53 - Choke Housing Assembly
54 - Gasket
55 - Screw
56 - Lever Assembly
57 - Screw
58 - Choke Piston
59 - Pin
60 - Plug, ball
61 - Welch Plug
62 - Plate, baffle
63 - Gasket
64 - Stat Cover and Coil Assembly *
65 - Screw
66 - Retainer

* *Model 2GV has electric choke element.*

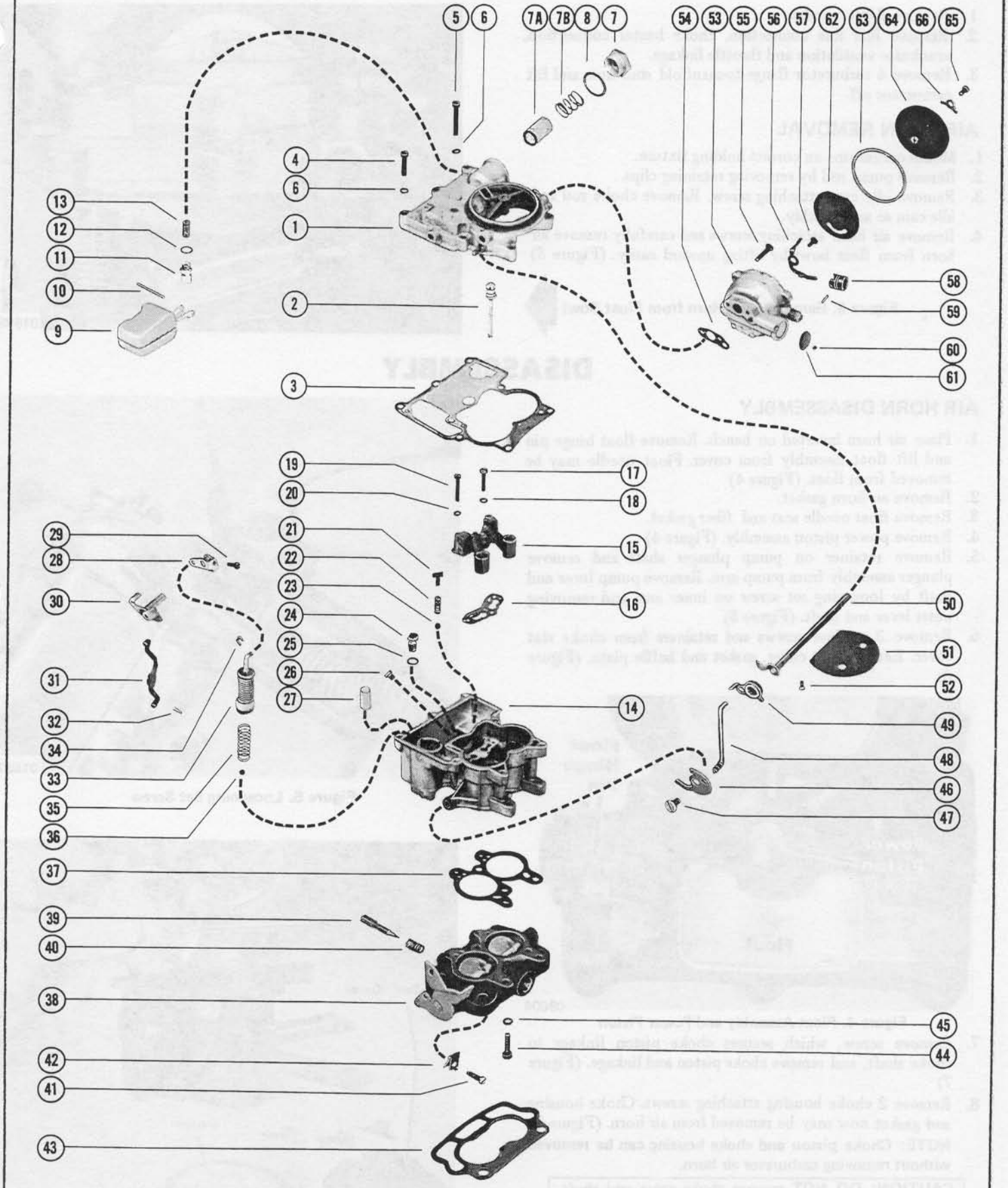


Figure 2. "2GC" Carburetor Assembly

REMOVAL

1. Remove flame arrestor.
2. Remove fuel line connection, choke heater connection, crankcase ventilation and throttle linkage.
3. Remove 4 carburetor flange-to-manifold stud nuts and lift carburetor off.

AIR HORN REMOVAL

1. Mount carburetor on correct holding fixture.
2. Remove pump rod by removing retaining clips.
3. Remove idle cam attaching screw. Remove choke rod and idle cam as an assembly.
4. Remove air horn attaching screws and carefully remove air horn from float bowl by lifting upward easily. (Figure 3)

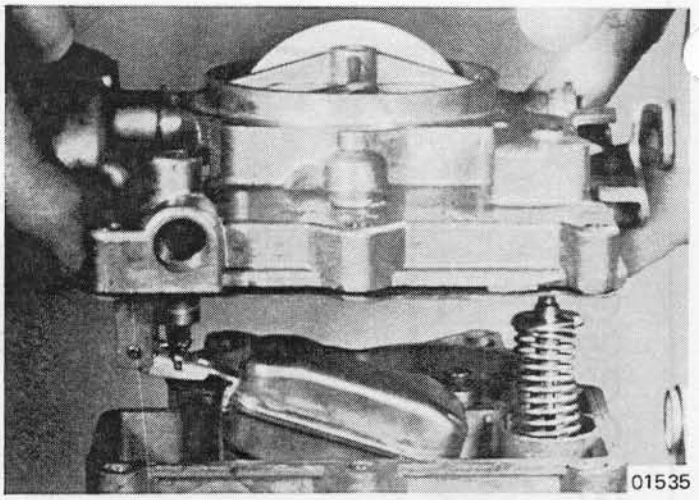


Figure 3. Removing Air Horn from Float Bowl

DISASSEMBLY

AIR HORN DISASSEMBLY

1. Place air horn inverted on bench. Remove float hinge pin and lift float assembly from cover. Float needle may be removed from float. (Figure 4)
2. Remove air horn gasket.
3. Remove float needle seat and fiber gasket.
4. Remove power piston assembly. (Figure 4)
5. Remove retainer on pump plunger shaft and remove plunger assembly from pump arm. Remove pump lever and shaft by loosening set screw on inner arm and removing outer lever and shaft. (Figure 5)
6. Remove 3 retainer screws and retainers from choke stat cover. Remove stat cover, gasket and baffle plate. (Figure 6)

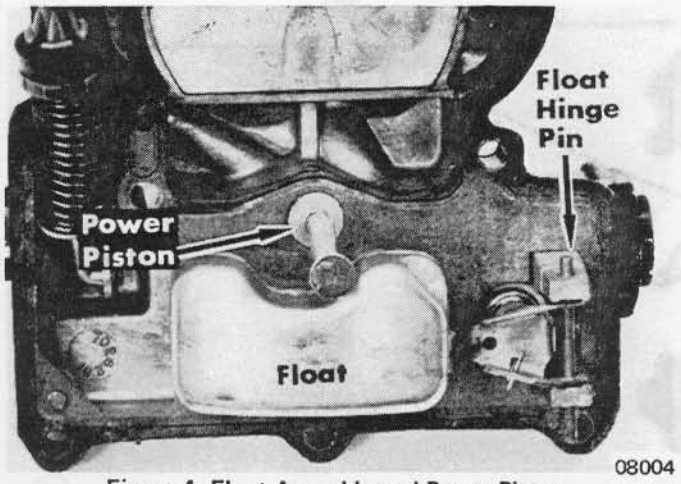


Figure 4. Float Assembly and Power Piston

7. Remove screw, which secures choke piston linkage to choke shaft, and remove choke piston and linkage. (Figure 7)
8. Remove 2 choke housing attaching screws. Choke housing and gasket now may be removed from air horn. (Figure 8)
   NOTE: Choke piston and choke housing can be removed without removing carburetor air horn.

CAUTION: DO NOT remove choke valve and shaft (Step 9), unless essential for repair purposes.

9. Remove 2 choke valve retaining screws (file off staked ends). Remove choke valve.

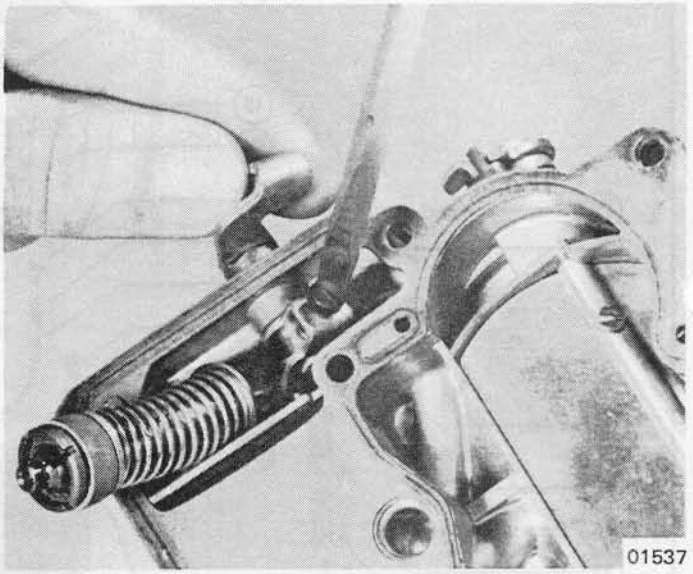


Figure 5. Loosening Set Screw

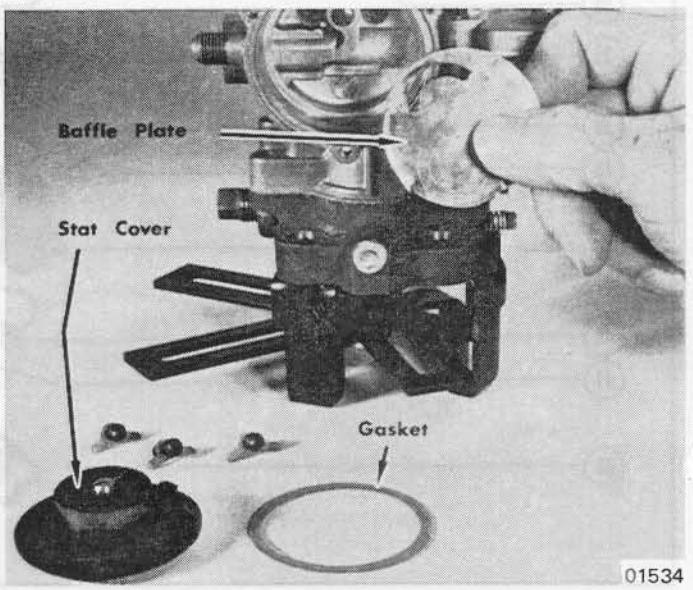


Figure 6. Removing Choke Stat Cover

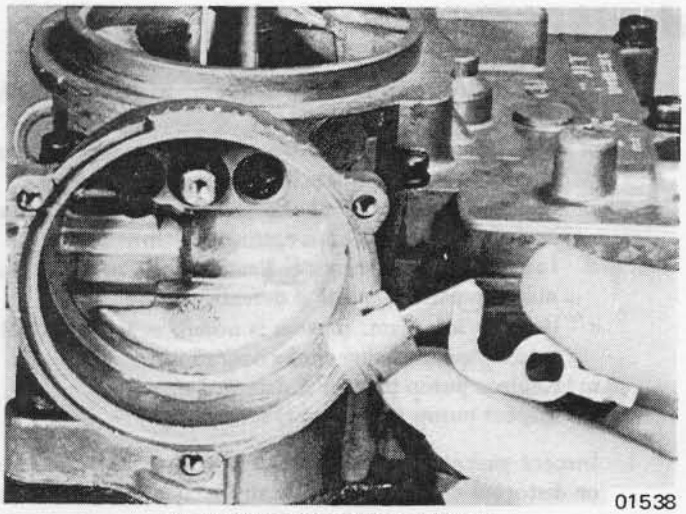


Figure 7. Freeing Choke Piston

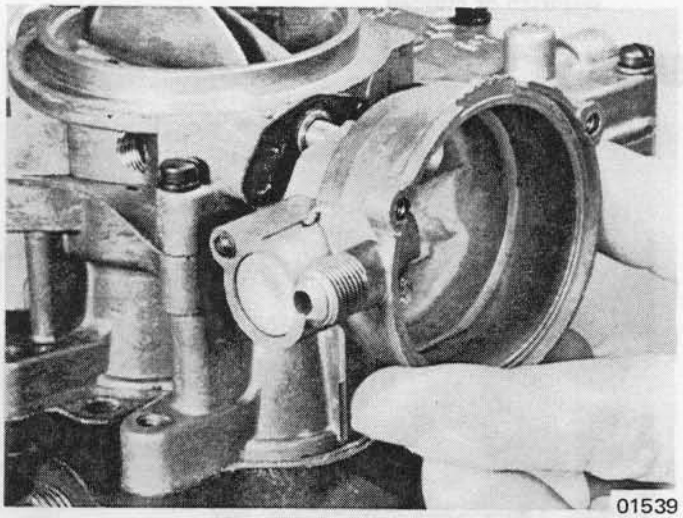


Figure 8. Removing Choke Housing

FLOAT BOWL DISASSEMBLY

1. Remove pump plunger return spring and check ball from pump well.
2. Remove pump inlet screen.
3. Remove main metering jets. (Figure 9)
4. Remove power piston check valve and gasket. (Figure 9)
5. Remove 3 attaching screws on top of venturi cluster, then remove cluster and gasket. Center cluster screw has smooth shank and fiber gasket for accelerator pump fuel passage.
6. Remove T-shaped retainer with a pair of long nose pliers. Remove pump discharge spring and steel discharge ball. (Figure 10)
7. Invert carburetor and remove 3 throttle body to bowl attaching screws. Remove throttle body and throttle body to bowl gasket.

THROTTLE BODY DISASSEMBLY

1. Remove idle mixture adjusting needles and springs.
2. Remove idle RPM adjusting screw from throttle lever, if replacement is necessary.
3. DO NOT remove throttle valves. If throttle valves and/or shaft is damaged, replace throttle body assembly.

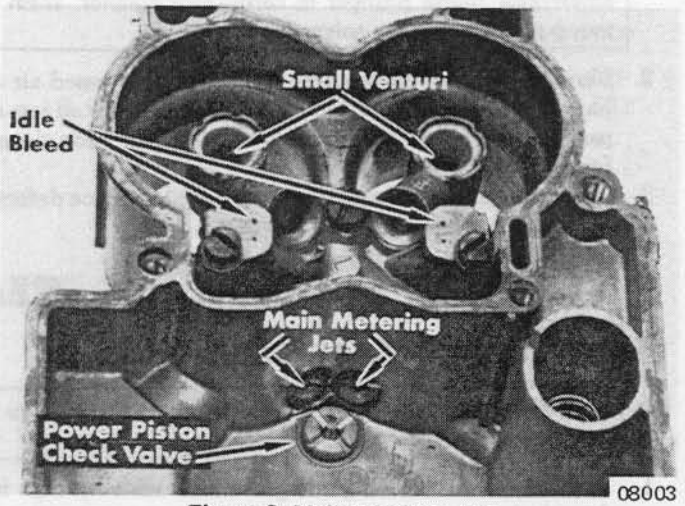


Figure 9. Main Metering Jets

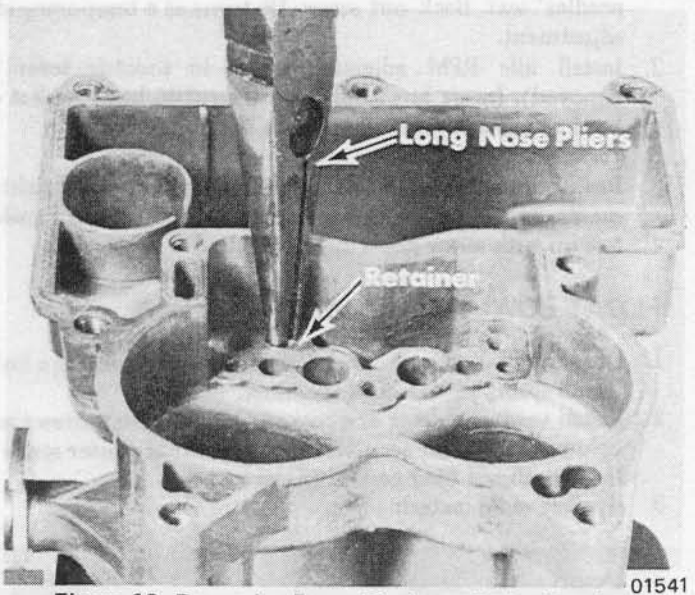


Figure 10. Removing Pump Discharge Spring Retainer

CLEANING and INSPECTION

Dirt, gum, water or carbon contamination in or on exterior moving parts of carburetor often are responsible for unsatisfactory performance. For this reason, efficient carburetion depends upon careful cleaning and inspection while servicing.

1. Thoroughly clean carburetor castings and metal parts in fresh cleaning solvent.

CAUTION: Never immerse choke stat cover and accelerator pump plunger in carburetor cleaner. Wash pump plunger in clean solvent.

2. Blow all passages in castings dry with compressed air and blow off all parts until they are dry. Make sure all jets and passages are clean. Do not use wires or drills for cleaning fuel passages or air bleeds.
3. Check all parts for wear. If wear is noted, replace defective parts. Note especially the following:
   a. Check float needle and seat for wear. If worn, replace assembly.
   b. Check float hinge for wear and float for dents and distortion. Check floats for fuel leaks by shaking.
   c. Check throttle and choke shaft bores for wear and out-of-round in air horn casting and throttle body.
   d. Inspect idle adjusting needles for burrs or grooves and misalignment. Replace if defective.
   e. Replace idle cam, if wear is noted, as wear may alter set idle speed during choke operation.
   f. Replace pump plunger if damaged or worn.
   g. Inspect pump well in bowl for wear.
4. Inspect gaskets for hard or brittle appearance or for torn or distorted edges. Replace, if any such condition is noted.
5. Check filter screens for dirt or lint. Clean and replace if distorted or plugged.

REASSEMBLY

THROTTLE BODY REASSEMBLY

CAUTION: Do not force idle needle against seat, or damage may result.

1. Screw idle mixture adjusting needles with springs into throttle body until they very lightly just touch adjusting needles' seat. Back out screw 1½ turns as a temporary idle adjustment.
2. Install idle RPM adjusting screw in throttle lever (if removed). Invert bowl, place new throttle body gasket on bowl and install throttle body on bowl.
3. Install throttle body to bowl attaching screws and tighten evenly and securely. Make sure that screw holes in gasket line up with screw holes in throttle body.

FLOAT BOWL REASSEMBLY

1. Drop pump discharge check ball (steel) into discharge hole. Install spring and T-shaped retainer.
2. Install venturi cluster and gasket. Install cluster screws and tighten evenly and securely. Make sure that center screw is fitted with red fiber gasket. (Figure 11)
3. Replace main metering jets.

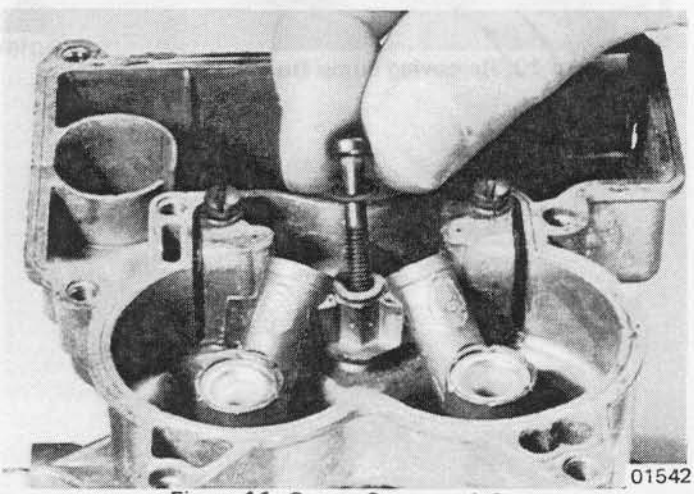


Figure 11. Center Screw and Gasket

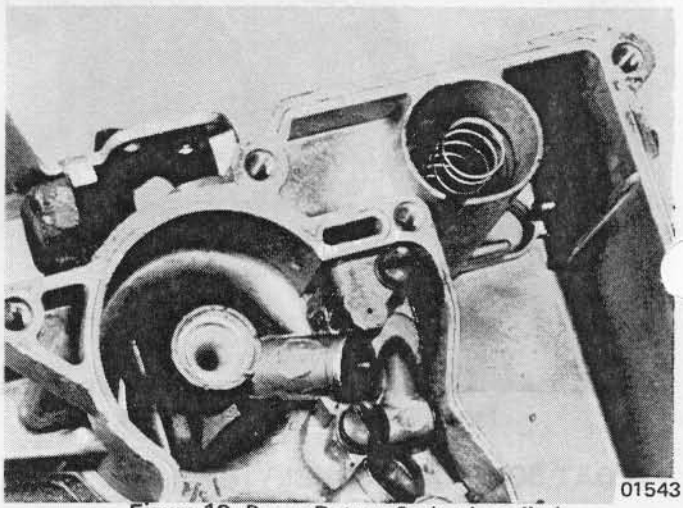


Figure 12. Pump Return Spring Installed

4. Place gasket on power piston check valve and install check valve. (Figure 9)
5. Install accelerator pump inlet screen and inlet check ball. Install pump return spring. Center spring in well by pressing downward with finger. (Figure 12)

AIR HORN REASSEMBLY

1. Place new choke housing gasket in position on air horn and install choke housing with 2 attaching screws tightened evenly and securely.
2. Assemble choke piston to choke shaft and link assembly, retaining with pin. Piston pin side of choke piston should face toward air horn. (Figure 13)

   NOTE: If choke valve was removed, center choke valve on choke shaft by installing choke lever and collar assembly and trip lever. Maintain .020" (.51mm) clearance between choke lever and air horn casting. Tighten choke valve screw and stake lightly in place.

3. Install choke piston and shaft assembly into bore in choke housing.
4. Install outer pump lever and inner pump arm to bowl cover and tighten set screw.

5. Attach pump plunger assembly to inner arm with pump shaft pointing inward and install horseshoe retainer. (Figure 14)
6. Install float needle seat and gasket in air horn. Tighten securely.
7. Install power piston assembly (Figure 4). Peen air horn housing around power piston to retain piston in housing.
8. Install air horn gasket on air horn.
9. Attach float needle to float, carefully position float and insert hinge pin.
10. Adjust float as outlined in "Adjustments", following.

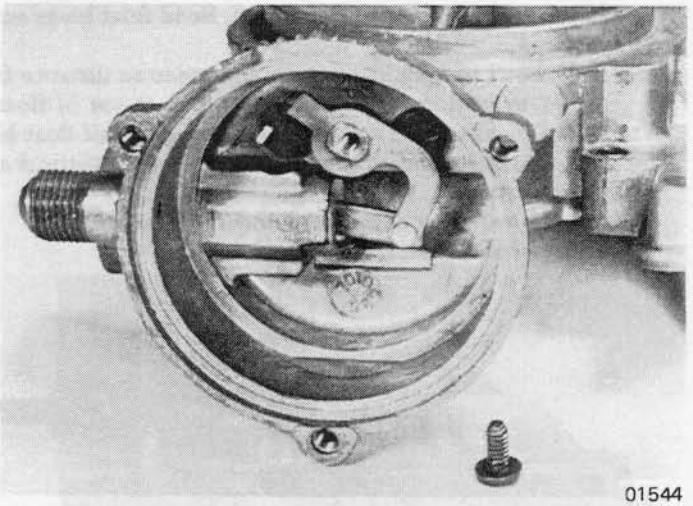


Figure 13. Positioning Piston

11. Place air horn on float bowl, making sure that accelerator pump plunger is positioned and will move freely. Lower cover gently straight down to ensure proper installation.
12. Install and tighten air horn screws evenly and securely.
13. Install accelerator pump rod and retainers.

CHOKE REASSEMBLY

1. Place baffle plate and choke stat cover gasket into position and install choke stat cover. Rotate cover until correct index marking is aligned. Attach 3 retainers and screws to choke housing and tighten securely.
2. Install choke rod in idle cam and choke counterweight lever. Install idle cam and choke rod as an assembly.
3. Attach idle cam to bowl (with letters "RP" facing outward) and choke lever to air horn. (Figure 15)

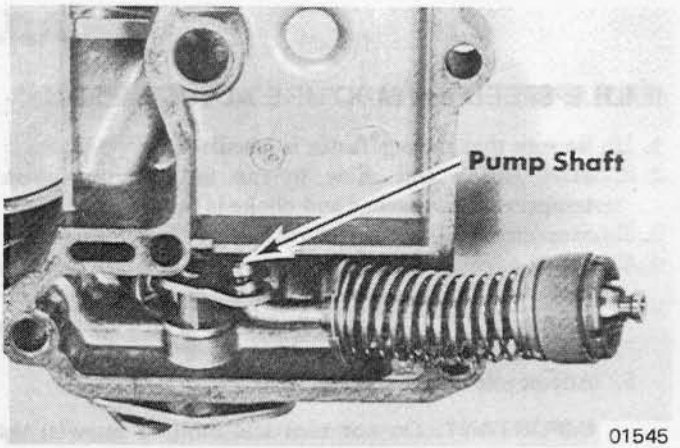


Figure 14. Attaching Pump Plunger

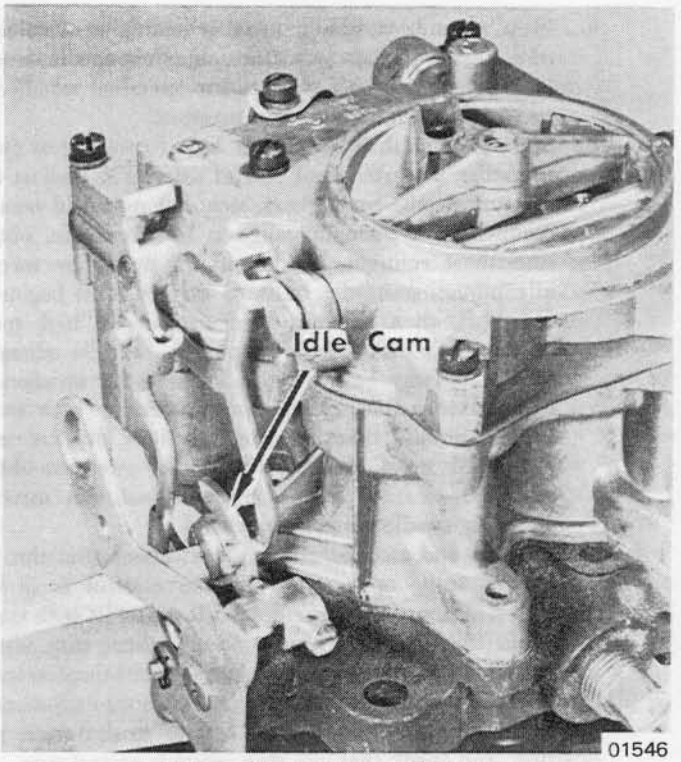


Figure 15. Attaching Idle Cam

INSTALLATION

1. Throttle body and intake manifold gasket surfaces must be clean.
2. Install new gasket and carburetor.
3. Install 4 nuts and tighten evenly.
4. Install choke heat tube and fuel line.
5. Install throttle and return spring.
6. Install flame arrestor.
7. Adjust idle speed and mixture as outlined in "Adjustments", following.

WARNING: After installation of carburetor, manually operate throttle for full open and close position to check for a binding or sticking condition of the throttle linkage. This is especially important in applications that include dashpots and other throttle acutated mechanisms. It may be necessary to remove and replace these mechanisms and carburetor throttle linkage parts on this carburetor. Failure to follow these procedures may result in uncontrolled engine speed. Inspect for fuel leaks.

ADJUSTMENTS

IDLE SPEED and MIXTURE ADJUSTMENTS

1. Be sure that flame arrestor is installed.
2. Start engine and allow to run until normal operating temperature is reached and choke is fully open.
3. Stop engine; disconnect throttle cable from engine.
4. Start engine; shift drive unit into forward gear (with propeller in water). Adjust idle speed screw to obtain recommended idle RPM as indicated in "Specifications" Section 8. Shift into neutral.
5. Adjust idle mixture screw(s).

   IMPORTANT: Do not turn idle mixture screw(s) tightly against stop, or mixture needle and/or seat will be damaged.

   a. Stop engine, turn idle mixture adjusting needles in until they very lightly just touch adjusting needle seat, then back needles off seats the specified number of turns for preliminary idle adjustment.
   b. Start engine, shift drive unit into forward gear (with propeller in water) and run at idle RPM. Adjust idle mixture needle for highest, steadiest manifold vacuum reading. If a vacuum gauge is not available, obtain smoothest running, maximum idle speed by turning idle adjusting needle in until engine RPM begins to drop off, then backing needle off over "high spot" until engine RPM again drops off. Set idle adjusting needle halfway between the 2 points for satisfactory idle mixture setting. Repeat procedure with other needle. Should these adjustments show an increase in idle RPM, reset idle speed adjusting screw to obtain specified idle RPM and again adjust idle mixture adjusting needle. Shift into neutral.
6. Stop engine and install throttle cable. Check that throttle valves are fully open when remote control is in full forward position. On MerCruiser 120-thru-470 with throttle valves fully open, turn wide-open throttle stop adjusting screw clockwise until screw just touches throttle lever. (Figure 16) Tighten set nut securely to prevent adjustment screw from turning. Return control to neutral gear, idle position, and check that idle stop screw is against stop.
   a. Shift unit into forward gear.
   b. Re-adjust idle speed screw to obtain recommended idle RPM.

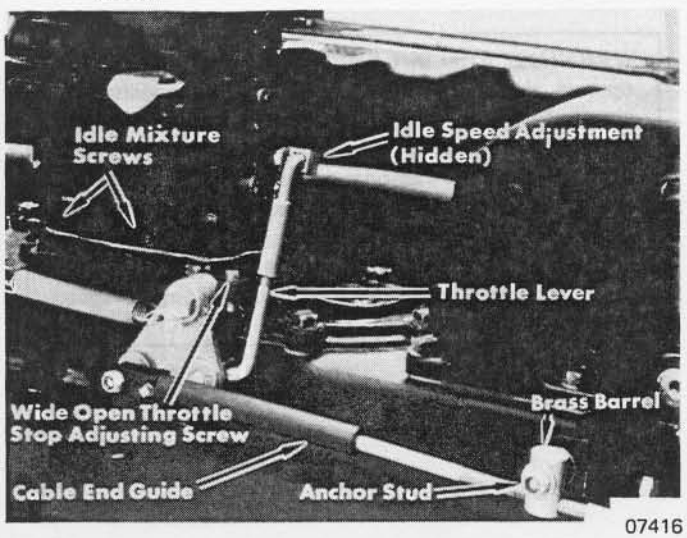


Figure 16. Idle Adjustment - MerCruiser 120-thru-470

FLOAT LEVER and DROP ADJUSTMENTS

For 2GC carburetors, use Figures 17 and 19. For 2GV carburetors, use Figures 18 and 20.

1. Remove bowl cover with gasket from carburetor as described under "Disassembly", preceding.
2. Invert cover on a flat surface. Distance from air horn gasket to toe of float at sharp edge of seam (Figure 17 or 18) should be within specification. Bend float hinge arm as required.
3. Hold bowl in upright position and measure distance from gasket to bottom of float or to notch at toe of float, as shown in Figure 19 or 20. Bend tang at end of float hinge arm to obtain correct drop and recheck both settings after this adjustment.
4. Install bowl cover as outlined under "Reassembly".
5. Readjust idle mixture.

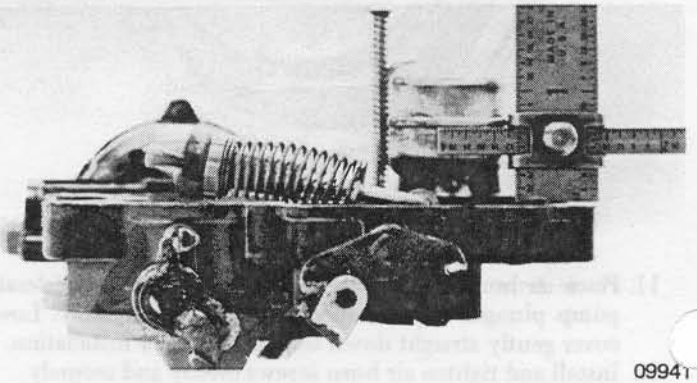


Figure 17. Float Adjustment on 2GC Carburetors

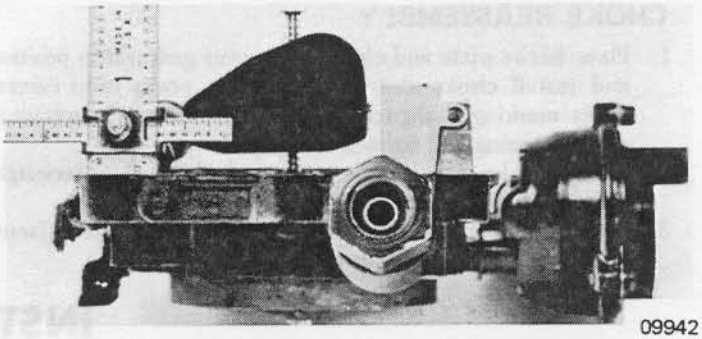


Figure 18. Float Adjustment on 2GV Carburetors

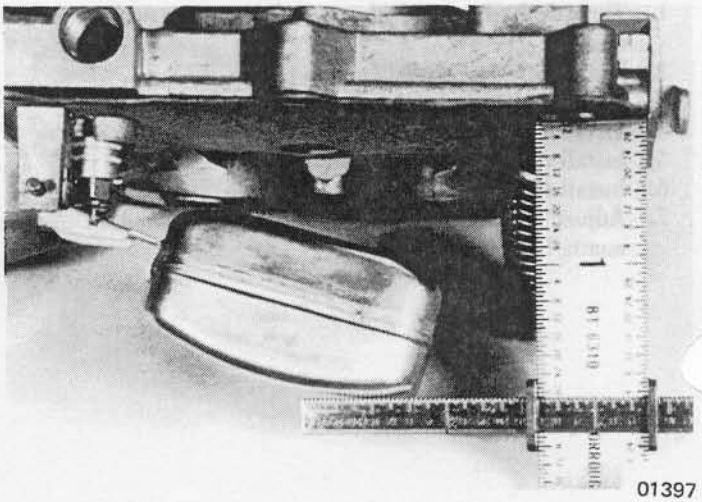


Figure 19. Float Drop Adjustment on 2GC Carburetors

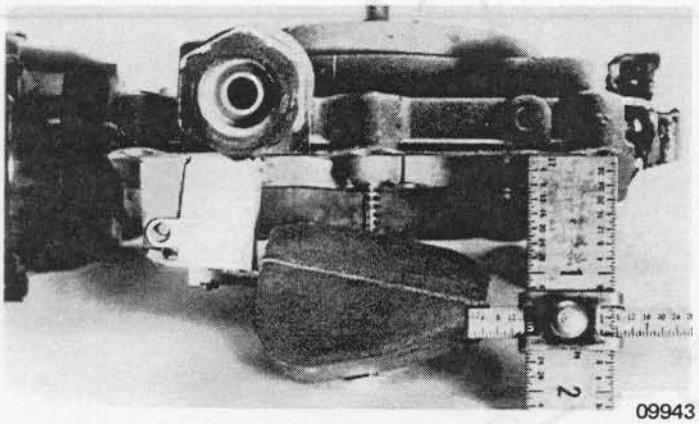


Figure 20. Float Drop Adjustment on 2GV Carburetors

PUMP ROD ADJUSTMENT

1. Back off idle screw until throttle valves are completely closed.
2. While holding throttle valves closed, check distance from area on top of carburetor (where flame arrestor sets) to top of pump rod, as shown in Figure 21.
3. Leg of gauge should just touch top of pump rod.
4. Bend accelerator pump rod carefully to obtain correct adjustment.

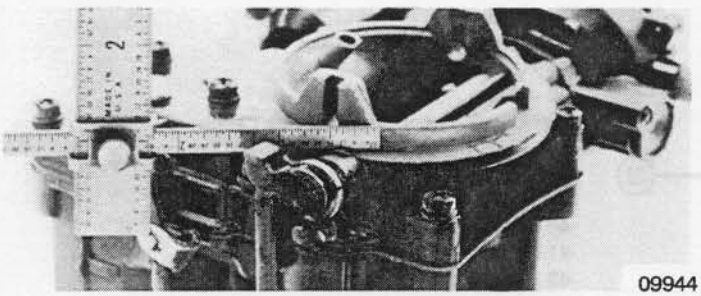


Figure 21. Pump Rod Adjustment

AUTOMATIC CHOKE ADJUSTMENT

Normal setting of choke is such that scribed mark on cover is in line with long case mark on choke housing casting.

No adjustment of fast speed is provided.

UNLOADER ADJUSTMENT

Check and make any necessary correction of unloader adjustment as follows:

1. Place throttle in wide-open position.
2. Using correct gauge, see if gauge just slides freely between upper edge of choke valve and bore of carburetor. (Figure 19)
3. If necessary, bend tang of throttle lever to obtain necessary clearance.

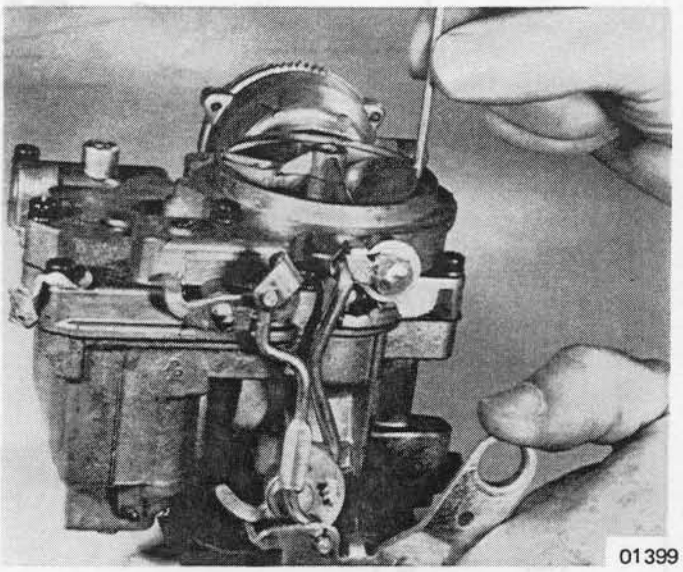
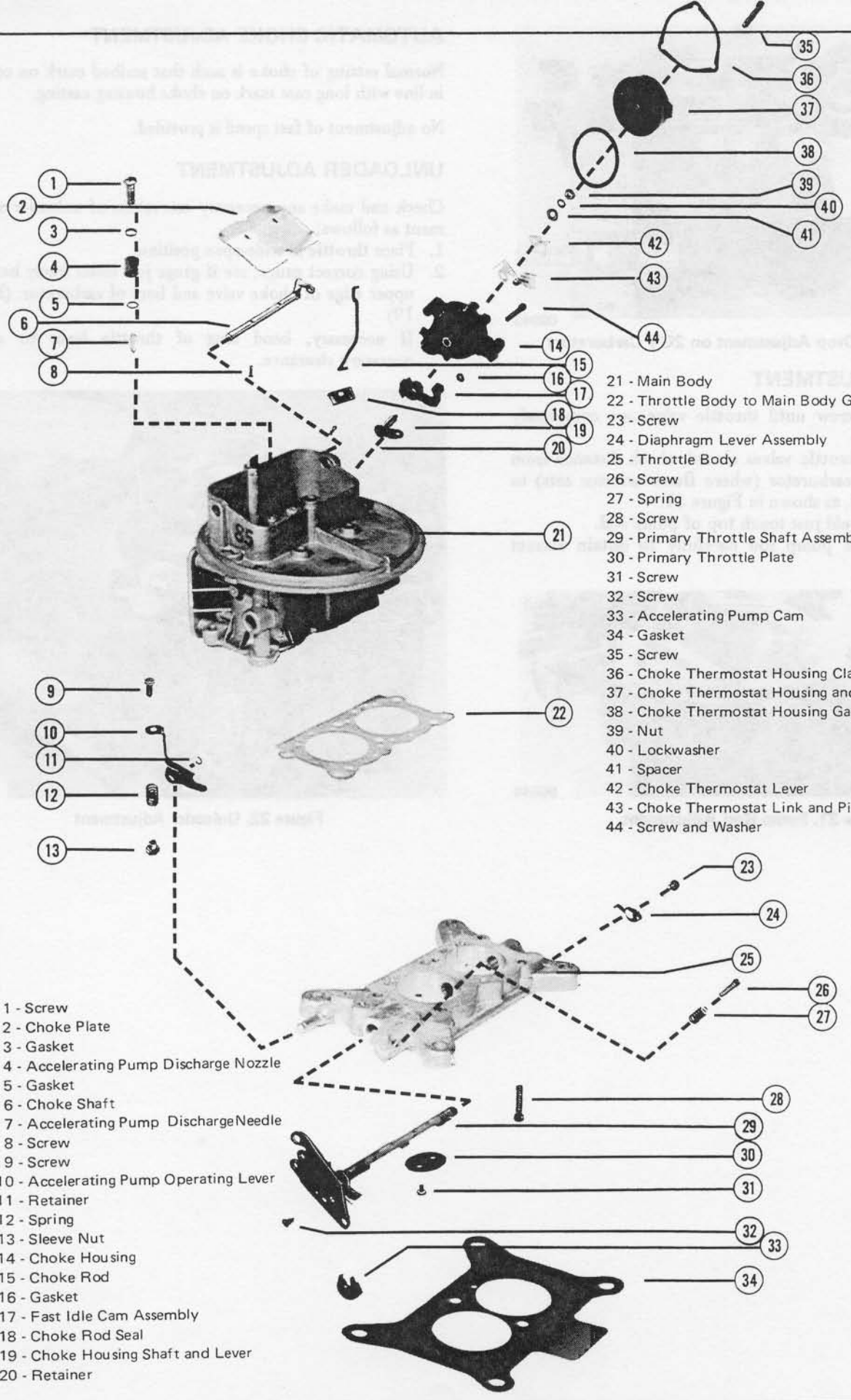
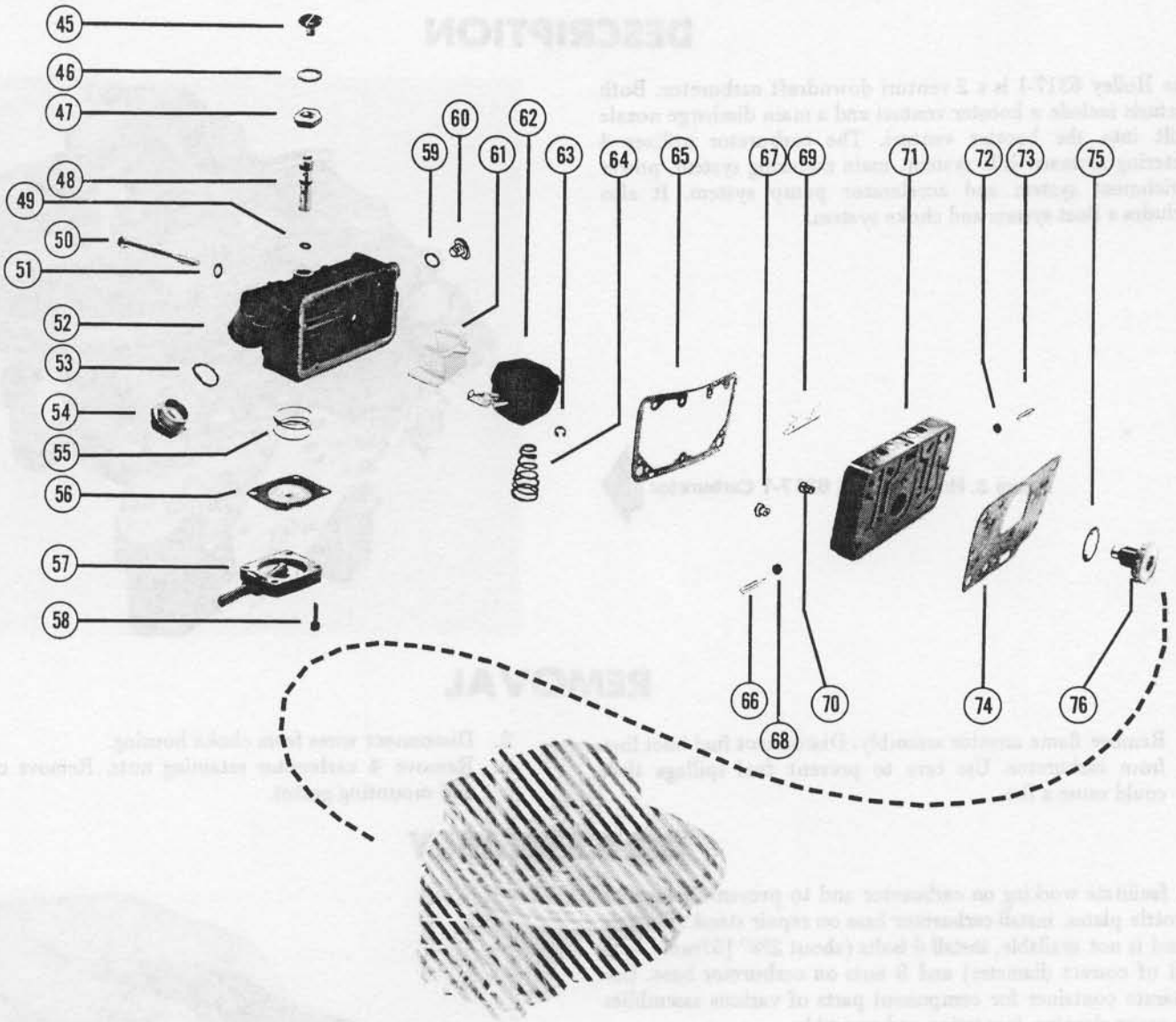


Figure 22. Unloader Adjustment



1 - Screw
2 - Choke Plate
3 - Gasket
4 - Accelerating Pump Discharge Nozzle
5 - Gasket
6 - Choke Shaft
7 - Accelerating Pump DischargeNeedle
8 - Screw
9 - Screw
10 - Accelerating Pump Operating Lever
11 - Retainer
12 - Spring
13 - Sleeve Nut
14 - Choke Housing
15 - Choke Rod
16 - Gasket
17 - Fast Idle Cam Assembly
18 - Choke Rod Seal
19 - Choke Housing Shaft and Lever
20 - Retainer
21 - Main Body
22 - Throttle Body to Main Body Gasket
23 - Screw
24 - Diaphragm Lever Assembly
25 - Throttle Body
26 - Screw
27 - Spring
28 - Screw
29 - Primary Throttle Shaft Assembly
30 - Primary Throttle Plate
31 - Screw
32 - Screw
33 - Accelerating Pump Cam
34 - Gasket
35 - Screw
36 - Choke Thermostat Housing Clamp
37 - Choke Thermostat Housing and Spring
38 - Choke Thermostat Housing Gasket
39 - Nut
40 - Lockwasher
41 - Spacer
42 - Choke Thermostat Lever
43 - Choke Thermostat Link and Piston Assembly
44 - Screw and Washer

Figure 1. Holley Carburetor Model 6317-1 Exploded View



45 - Lockscrew
46 - Gasket
47 - Fuel Level Adjusting Nut
48 - Fuel Inlet Needle and Seat
49 - "O" Ring Seal
50 - Screw
51 - Gasket
52 - Primary Fuel Bowl
53 - Gasket
54 - Fuel Inlet Fitting
55 - Diaphragm Spring
56 - Diaphragm Assembly
57 - Accelerating Pump Cover
58 - Retaining Screw and Lockwasher
59 - Gasket
60 - Fuel Level Sight Plug
61 - Baffle Plate
62 - Float
63 - Retainer
64 - Float Spring
65 - Primary Fuel Bowl Gasket
66 - Idle Adjusting Needle
67 - Main Jet
68 - Seal
69 - Baffle Plate
70 - Main Jet
71 - Primary Metering Block
72 - Seal
73 - Idle Adjusting Needle
74 - Primary Metering Block Gasket
75 - Power Valve Gasket
76 - Power Valve

Figure 2. Holley Carburetor - Exploded View (Continued)

HOLLEY MODEL 6317-1 CARBURETOR

DESCRIPTION

The Holley 6317-1 is a 2 venturi downdraft carburetor. Both venturis include a booster venturi and a main discharge nozzle built into the booster venturi. The carburetor utilizes 4 metering systems: Idle system, main metering system, power enrichment system and accelerator pump system. It also includes a float system and choke system.

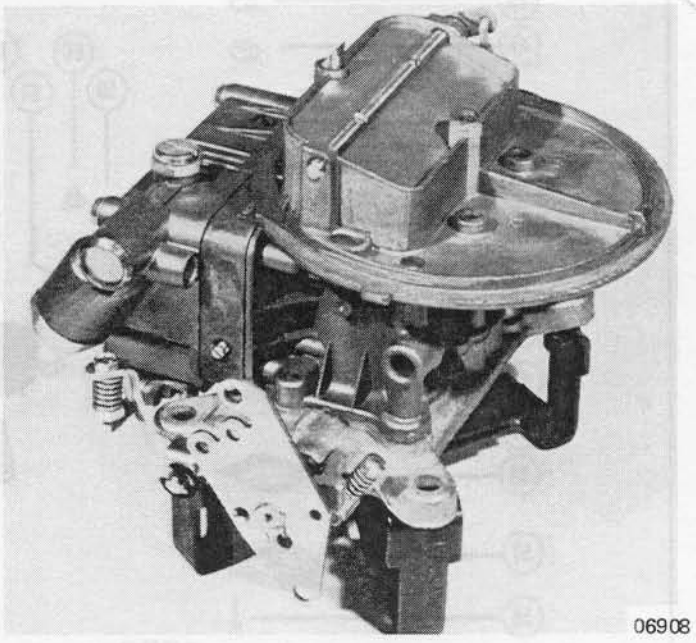


Figure 3. Holley Model 6317-1 Carburetor

REMOVAL

1. Remove flame arrestor assembly. Disconnect fuel inlet line from carburetor. Use care to prevent fuel spillage that could cause a fire.
2. Disconnect wires from choke housing.
3. Remove 4 carburetor retaining nuts. Remove carburetor and mounting gasket.

DISASSEMBLY

To facilitate working on carburetor and to prevent damage to throttle plates, install carburetor base on repair stand. If repair stand is not available, install 4 bolts (about 2¼" [57mm] long and of correct diameter) and 8 nuts on carburetor base. Use separate container for component parts of various assemblies for easier cleaning, inspection and assembly.

Following is a step-by-step sequence of operations for completely overhauling the carburetor. However, certain carburetor components may be serviced without a complete disassembly. For complete carburetor overhaul, follow all steps. For partial overhaul or to install a new gasket kit, follow only the applicable steps.

Refer to Figures 1 and 2 for identification of parts used on Holley Carburetor.

FUEL BOWL and METERING BLOCK DISASSEMBLY

Refer to Figures 1 and 2 for correct location of fuel bowl parts.

1. Remove fuel bowl and gasket and metering block and gasket. Discard gaskets.
2. Remove idle adjusting needles and gaskets. Discard gaskets.
3. Remove main jets with screwdriver. (Figure 4)
4. Remove power valve and gasket with socket wrench. (Figure 5)
5. Remove fuel level adjustment lockscrew and gasket. Turn adjusting nut counterclockwise and remove locknut and gasket. Remove fuel inlet needle and seat assembly. DO NOT disassemble fuel inlet needle and seat, as they are matched assemblies and are replaced as an assembly.
6. Remove float retainer with needle-nose pliers. (Figure 6) Slide float off shaft. Remove spring form float.
7. Remove baffle plate from fuel bowl.
8. Remove fuel level sight plug and gasket.
9. Remove fuel inlet fitting and gasket.
10. Invert fuel bowl and remove accelerating pump cover, diaphragm and spring. Accelerating pump inlet check ball is not removable.

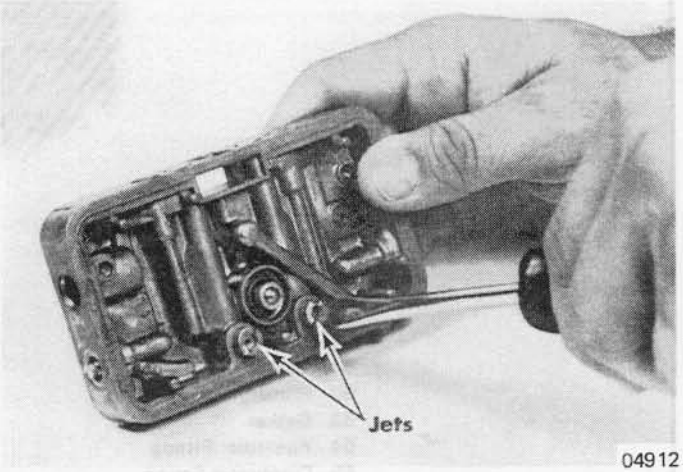


Figure 4. Main Jet Removal

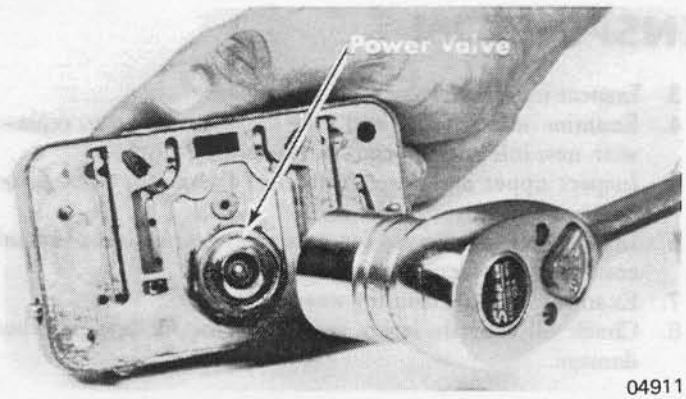


Figure 5. Power Valve Removal

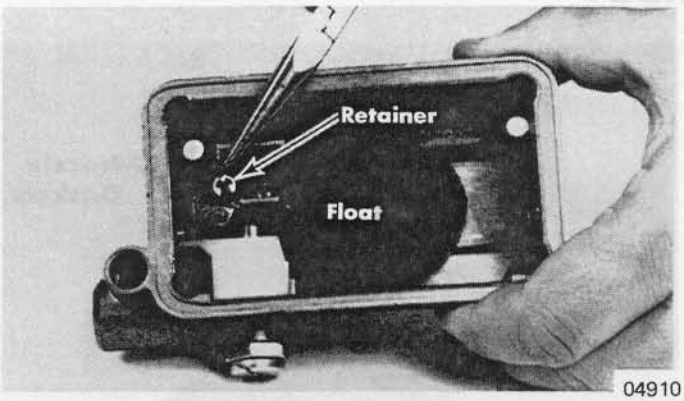


Figure 6. Float Shaft Retainer Removal

MAIN BODY DISASSEMBLY

1. Remove flame arrestor anchor stud.
2. Invert carburetor and remove throttle body retaining screws and lockwashers. Lift off throttle body and discard throttle body gasket.
3. Remove choke rod retainer from choke housing shaft and lever assembly. Remove thermostatic spring housing and gasket, then remove choke housing and gaskets from main body. Remove choke housing shaft nut, lockwasher and spacer, then remove shaft and fast idle cam. Remove choke piston and lever assembly. Remove choke rod and seal from main body. If necessary, remove choke plate from choke shaft and slide shaft and lever out of air horn. Retaining screws are staked to choke shaft. If tips of screws are flared excessively, file off flared portion to avoid damage to threads in choke shaft. Be careful not to damage choke shaft or venturi while filing screws.
4. Remove accelerating pump discharge nozzle screw and lift pump discharge nozzle and gaskets out of main body. Invert main body to allow accelerating pump discharge needle to drop out into hand.

THROTTLE BODY DISASSEMBLY

1. Remove accelerating pump operating lever retainer.
2. If necessary, remove throttle stop screw and spring.
3. If necessary to remove throttle plates, lightly scribe throttle plates along throttle shaft and mark each plate and its corresponding bore with a number or letter for proper reinstallation. (Figure 7) Remove throttle plates. Retaining screws are staked to throttle shaft. If tips of screws are flared excessively, file off flared portion to avoid thread damage in throttle shaft. Be careful not to damage throttle shaft of venturi while filing screws.
4. Remove fast idle cam lever. Remove throttle shaft return spring from notch on throttle shaft lever. (Figure 1) Slide throttle lever and shaft assembly out of throttle body. Remove accelerating pump cam.

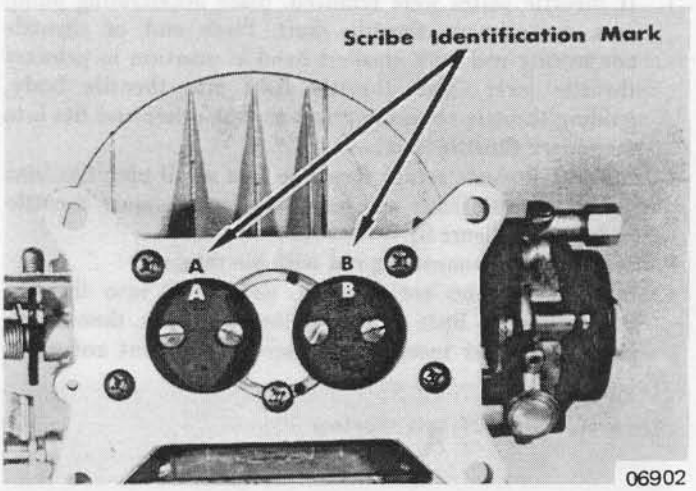


Figure 7. Throttle Plate Removal

CLEANING and INSPECTION

1. Clean carburetor in a cold immersion-type cleaner, such as Carbon-X (X-55) or its equivalent.

CAUTION: DO NOT immerse any rubber parts, plastic parts, diphragms and pump plungers in carburetor cleaner. Delrin cam on air throttle lever will withstand normal cleaning in carburetor cleaner.

2. Blow out all passages in castings with compressed air. DO NOT pass drills thru jets or passages.
3. Inspect idle mixture needles for damage.
4. Examine inlet needle and seat for wear. If worn, replace with new inlet needle and seat assembly.
5. Inspect upper and lower surfaces of carburetor castings for damage.
6. Inspect holes in levers for excessive wear or out-of-round condition. If worn, replace levers.
7. Examine fast idle cam for wear or damage.
8. Check all throttle levers and valves for binding or other damage.

REASSEMBLY

NOTE: Make sure that all holes in new gaskets are properly punched and that no foreign material adheres to gaskets. Be certain that accelerating pump diaphragms are not cut or torn.

Carburetor assembly is shown in Figures 1 and 2, preceding.

THROTTLE BODY REASSEMBLY

Refer to Figure 8 for correct location of parts.

1. If throttle plates were removed, place accelerating pump cam on primary throttle shaft. Place end of throttle connecting rod with smallest bend in position in primary throttle lever. Slide throttle shaft into throttle body, guiding throttle connecting rod so that other end fits into secondary throttle lever.
2. Position throttle return spring so that small tang fits into slot in throttle lever and long tang rests against throttle body stop. (Figure 8)
3. Secure end of connecting rod with pin retainer.
4. If throttle plates are removed, slide shaft into throttle body. Refer to lines scribed on throttle plates, then install plates in proper location with screws snug but not tight.

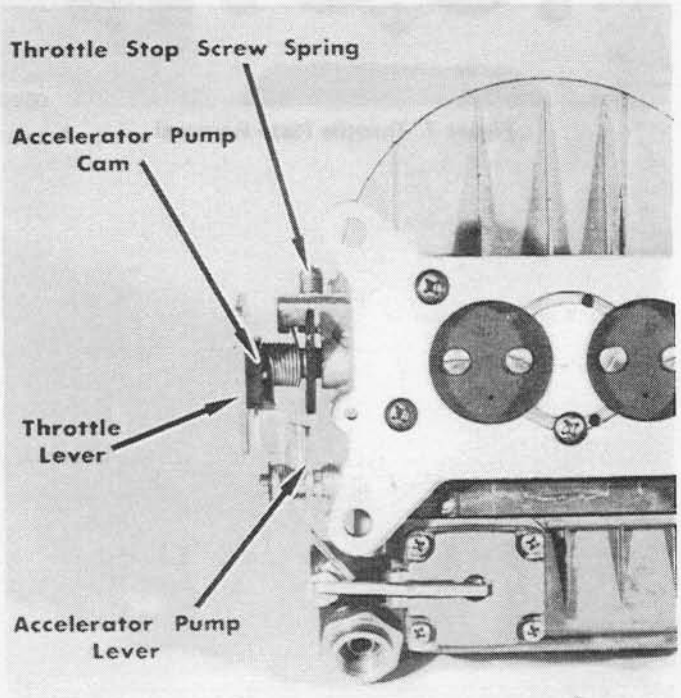


Figure 8. Throttle Lever and Shaft Assembly Installation

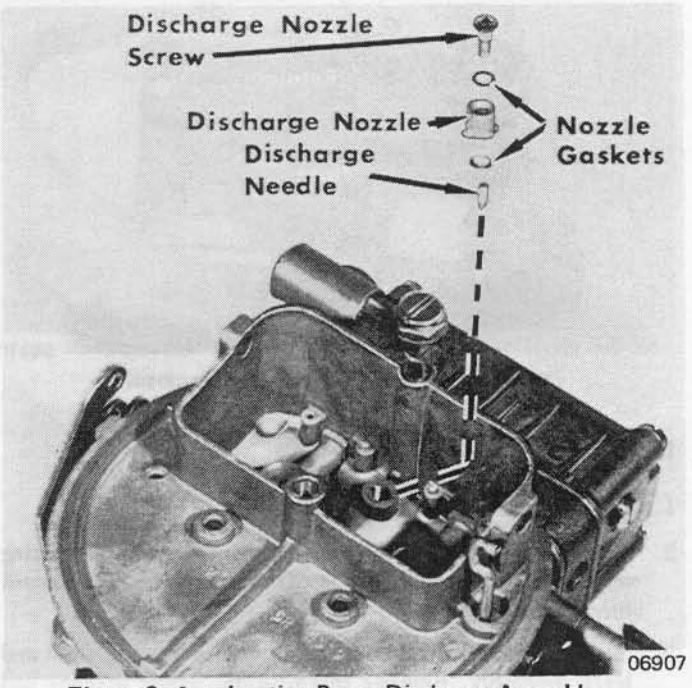


Figure 9. Accelerating Pump Discharge Assembly

Close throttle plates and hold throttle body up to the light. Little or no light should be visible between throttle plates and throttle bores. If throttle plates are properly installed and no binding exists when throttle shaft is rotated, tighten throttle plate screws. Stake screws by supporting shaft and plates on block of wood or soft metal bar to prevent shaft from bending.

5. Install fast idle cam lever, lockwasher and screw.
6. Install throttle stop screw and spring.
7. Install accelerating pump operating lever and retainer.

MAIN BODY REASSEMBLY

1. Drop accelerator pump discharge needle into its well. (Figure 9) Lightly seat needle with brass drift and hammer. Position accelerating pump nozzle and gaskets in main body and install retaining screw.
2. Position choke plate shaft in air horn and install choke plate in shaft. (Figure 1) Install rod seal on choke rod.Slide U-shaped end of choke plate rod thru opening in main body and insert rod end thru inner side of bore in choke lever. Rod end must face outward. Push rod real into retaining grooves on underside of flame arrestor mounting flange. Position choke thermostat lever link and piston assembly in choke housing. Position fast idle cam assembly on choke housing and install choke housing shaft and lever

assembly. (Figure 1) Position lever and piston assembly on choke housing shaft and lever assembly. Install spacer, lockwasher and nut. Place main body assembly on its side and position choke housing gaskets on main body. Insert choke rod in choke housing shaft lever as choke housing is placed into position on main body. Be sure that projection on choke rod is placed under fast idle cam so that cam will be lifted when choke plate is closed. Install choke rod cotter pin with needle-nose pliers.

Place thermostatic spring housing gasket into position on choke housing (engaging thermostatic spring on spring lever), then install housing clamp amd screws. Adjust thermostatic spring housing by aligning index mark on cover with mid-position mark on choke housing.

3. Invert main body and position throttle body gasket on main body. Place throttle body on main body so that fuel inlet fittings will be on same side as accelerating pump operating lever. Install throttle body to main body screws and lockwashers.
4. Install flame arrestor anchor stud.

FUEL BOWL and METERING BLOCK REASSEMBLY

Refer to Figures 1 and 2 for correct location of fuel bowl parts.

1. Place accelerating pump diaphragm spring and diaphragm in accelerating pump chamber. Disphragm must be positioned so that large end of lever disc will be against operating lever. Install cover and tighten retaining screws finger-tight. Make sure that diaphragm is centered, then compress diaphragm with pump operating lever and tighten cover screws. After carburetor is assembled, refer to "Adjustments" for correct adjustment of accelerating pump, following.
2. Install gasket and fuel inlet fitting.
3. Install fuel level sight plug and gasket.
4. Slide baffle plate onto ridges in fuel bowl.
5. Install float spring on float and slide float onto shaft. Be sure that float spring is between ridges on boss on floor of fuel bowl. Install float retainer with needle-nose pliers.
6. Apply petroleum jelly to new "O" ring seal and slide on fuel inlet needle and seat assembly.
7. Position fuel inlet needle and seat assembly in fuel bowl thru top of bowl. Position adjusting nut gasket and nut of fuel inlet needle and seat assembly. Align flat on ID of nut with flat on OD of fuel inlet needle and seat assembly. Install fuel level adjustment lockscrew and gasket.
8. As a preliminary float adjustment, refer to "Adjustments", following, and perform "Float Level Adjustment (Dry)" procedure.
9. Install power valve and gasket in metering block with socket wrench. (Figure 5) Be sure to install correct power valve. Refer to specifications for correct identification number (stamped on flat on base of valve).
10. Install jets in metering block with screwdriver. (Figure 4)
11. Install idle adjusting needles and new gaskets. Turn idle adjusting needles in until they just touch the seat, then back needles off the specified number of turns for a preliminary idle adjustment.
12. Position metering block gasket on dowels (located on back of metering block). Position metering block and gasket on main body. Position baffle plate and gasket on metering block. Place retaining screws and new compression gaskets in fuel bowl. Position bowl on metering block and tighten retaining screws.

INSTALLATION

1. Be sure that all old gasket material is removed from manifold and carburetor mounting flanges. Place new carburetor mounting gasket on manifold.
2. Position carburetor on spacer block. Connect choke heat wires to carburetor. Install carburetor retaining nuts and tighten evenly and alternately to specifications.
3. Connect fuel to float bowl.
4. Adjust engine idle speed and idle fuel mixture. Refer to "Adjustments", following, for proper procedure.
5. Install flame arrestor.

WARNING: Check all connections for fuel leaks.

ADJUSTMENTS

Fuel level float adjustment (dry) is performed only as a bench adjustment. Preliminary idle fuel mixture and idle speed adjustments, automatic choke adjustment and accelerating pump lever and stroke adjustments can be performed with carburetor on bench or installed on engine.

Fuel level adjustment, carburetor linkage adjustment, idle fuel mixture and idle speed adjustments are performed only with carburetor installed on engine.

FLOAT LEVEL ADJUSTMENT (DRY)

With float bowl upside down, adjust float parallel to bowl floor (Figure 10) by loosening lockscrew and turning adjusting nut.

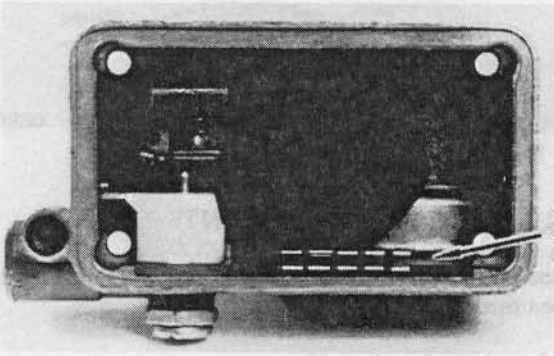


Figure 10. Dry Float Level Adjustment

ACCELERATOR PUMP LEVER CLEARANCE

1. With throttle valves at wide open throttle and pump lever held down, insert gauge between adjusting nut and operating lever. (Figure 11)
2. Adjust pump over-ride screw until correct clearance is obtained.

NOTE: There must be no free movement of pump lever when throttle is at idle.

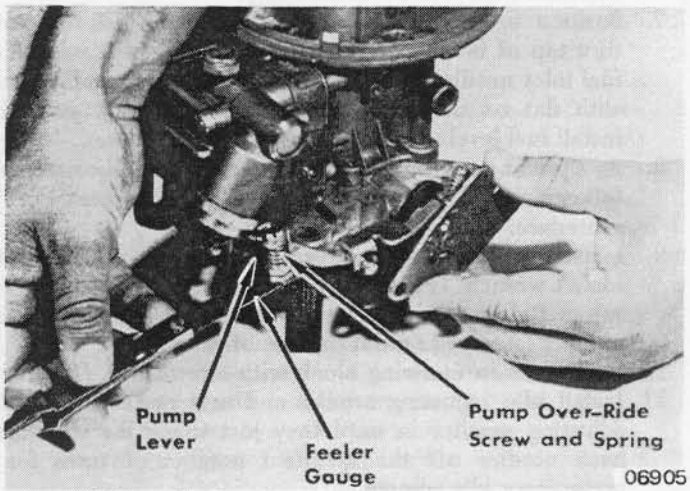


Figure 11. Accelerator Pump Lever Clearance

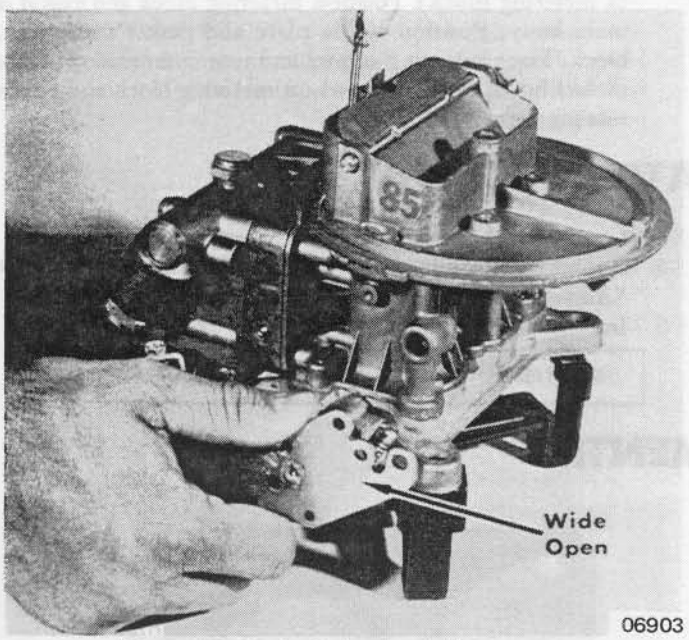


Figure 12. Choke Unloader Adjustment

CHOKE UNLOADER ADJUSTMENT

Choke unloader is a mechanical device to partially open choke at wide open throttle. Adjust as follows:

1. Hold throttle valves in wide open position, insert drill between upper edge of choke valve and inner wall of air horn.
2. Press finger lightly against choke control lever. A slight drag should be felt as drill is pulled out. (Figure 12)
3. To adjust, bend tab on kick-down lever until correct opening has been obtained.

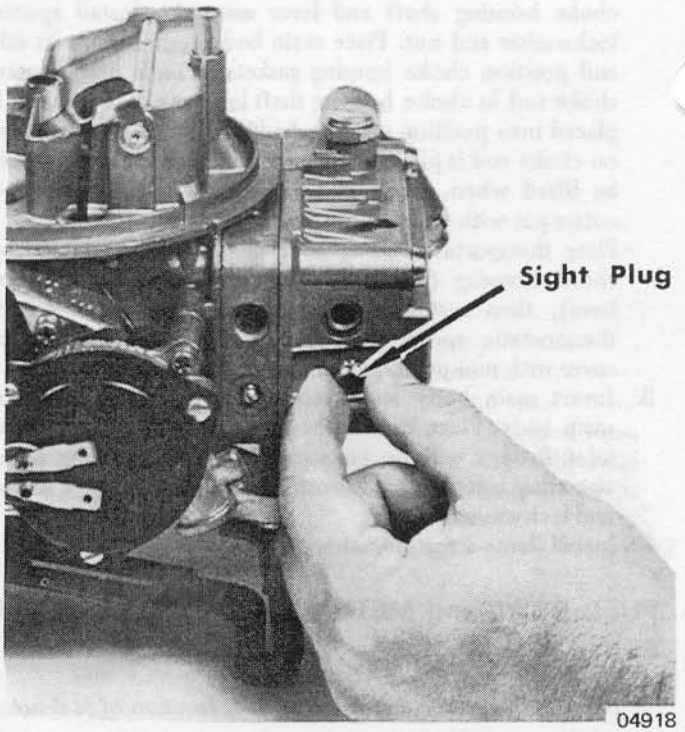


Figure 13. Removing Sight Plug

FLOAT LEVEL ADJUSTMENT (WET)

1. With flame arrestor removed and ignition "off", remove sight plug (Figure 13), then remove bowl lower attaching screw furthest from fuel inlet. (Figure 14)
2. Drain off fuel into a shallow pan, using care not to spil fuel and create a fire hazard.
3. Reinstall fuel bowl screw.
4. With engine running, fuel level should be in line with threads at bottom of sight plug port (plus-or-minus 1/32" [.8mm] tolerance).
5. To correct fuel level, loosen lockscrew (Figure 15) and turn adjusting nut clockwise to lower fuel level and counterclockwise to raise fuel level (1/6-turn of adjusting nut equals approximately 1/16" [1.6mm] in fuel level).

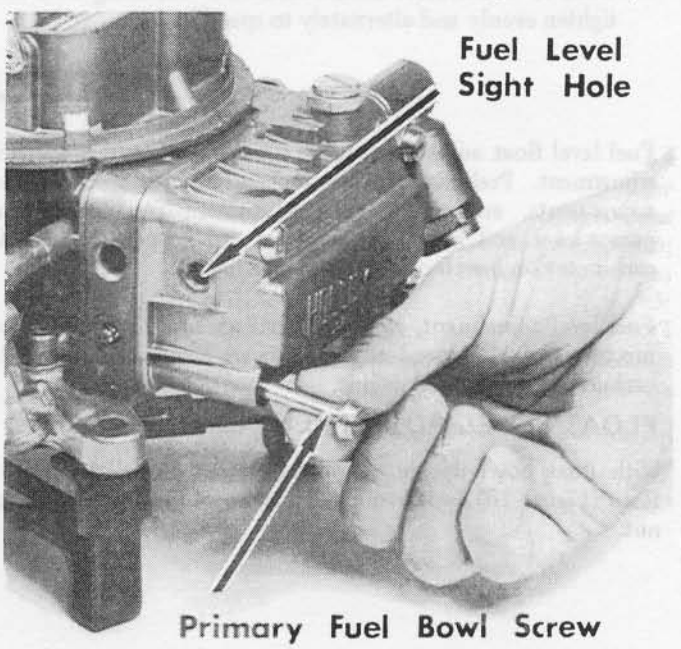


Figure 14. Removing Fuel Bowl Lower Screw

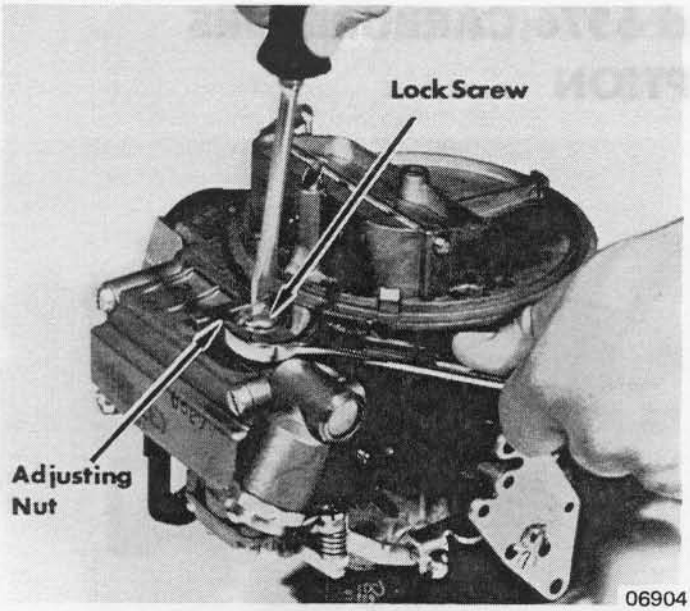


Figure 15. Adjusting Fuel Level

6. After adjustment, tighten lockscrew.
7. Operate engine until fuel level is stablized, then recheck level at sight plug.
8. If necessary, repeat adjustment until proper fuel level is attained.
9. Replace sight plug.

IDLE SPEED and MIXTURE ADJUSTMENT

1. Adjustment must be made with boat as level as possible.
2. Seat idle adjusting needles lightly and back each off a full turn, if there is doubt that this was not done during reassembly. (Figure 16)

   NOTE: When seating idle adjusting needle, care must be taken not to turn screw tight against seat, thus grooving tip of needle. If needle becomes grooved, a smooth idle cannot be obtained.

3. Start engine and allow operating temperature to reach normal.
4. After engine reaches normal operating temperature, adjust idle speed screw to idle engine at specified RPM.
5. First, set one of the 2 idle adjusting needles for highest steady manifold vacuum reading. If a vacuum gauge is not available, obtain smoothest-running, maximum idle speed by turning idle adjusting needle in until RPM begins to drop off, then backing needle off over "high spot" until RPM again drops off. Set idle adjusting needle halfway between 2 points for satisfactory idle mixture setting. Repeat procedure with other needle. Should these adjustments show an increase in idle RPM, reset idle speed screw to obtain specified idle RPM and again adjust idle adjusting needles.

AUTOMATIC CHOKE ADJUSTMENT

1. Automatic choke is set accurately at factory to give best possible all-weather operation. To return choke to original setting, line up index mark with proper specification.
2. If, for some reason, a richer or leaner mixture during warmup period is desired, it can be obtained by rotating thermostat cover. Never set index mark on cover more than 2 graduations off specified settings.

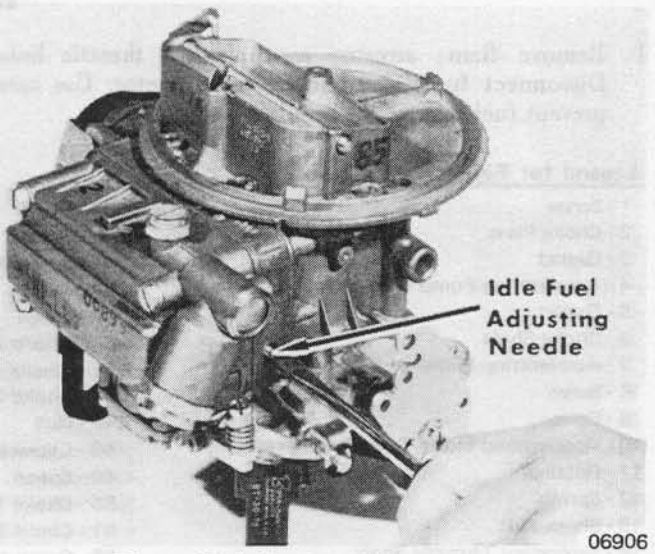


Figure 16. Adjusting Idle Fuel Mixture

HOLLEY MODEL 6407 and 6576 CARBURETORS

DESCRIPTION

Holley Models 6407 and 6576 are 4 venturi downdraft carburetors. The primary stage supplies fuel-air mixture throughout the entire range of operation, and the secondary stage operates when a greater quantity of fuel-air mixture is required. Both sides or stages of the carburetor contain a fuel bowl, fuel inlet valve, float and metering block.

In addition, the primary side includes the accelerator pump and air horn and choke system.

All venturis include a booster venturi and a main discharge nozzle built into the booster venturi.

The carburetor utilizes 4 metering systems: Idle system, main metering system, power enrichment system and accelerator pump system.

Also, there are float systems, a choke system and a secondary operation system.

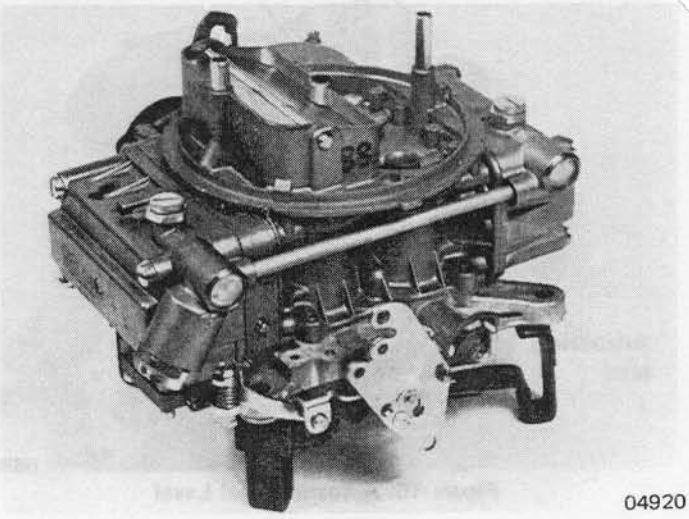


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Figure 1. Holley Carburetor

REMOVAL

1. Remove flame arrestor assembly and throttle linkage. Disconnect fuel inlet line from carburetor. Use care to prevent fuel spillage that could cause a fire.
2. Disconnect wires from choke housing.
3. Remove 4 carburetor retaining nuts. Remove carburetor and gasket.

Legend for Figure 2 and Figure 3

1 - Screw
2 - Choke Plate
3 - Gasket
4 - Accelerating Pump Discharge Nozzle
5 - Gasket
6 - Choke Shaft
7 - Accelerating Pump Discharge Needle
8 - Screw
9 - Screw
10 - Accelerating Pump Operating Lever
11 - Retainer
12 - Spring
13 - Sleeve Nut
14 - Secondary Throttle Shaft
15 - Secondary Throttle Plate
16 - Screw
17 - Throttle Connecting Rod
18 - Retainer
19 - Choke Housing
20 - Choke Rod
21 - Gasket
22 - Fast Idle Cam Assembly
23 - Choke Rod Seal
24 - Choke Housing Shaft and Lever
25 - Retainer
26 - Main Body
27 - Throttle Body to Main Body Gasket
28 - Screw
29 - Screw
30 - Diaphragm Lever Assembly
31 - Fast Idle Cam Lever
32 - Throttle Body
33 - Screw
34 - Spring
35 - Screw
36 - Screw
37 - Primary Throttle Shaft Assembly
38 - Primary Throttle Plate
39 - Screw
40 - Screw
41 - Accelerating Pump Cam
42 - Gasket
43 - Screw
44 - Choke Thermostat Housing Clamp
45 - Choke Thermostat Housing and Spring
46 - Choke Thermostat Housing Gasket
47 - Nut
48 - Lockwasher
49 - Spacer
50 - Choke Thermostat Lever
51 - Choke Thermostat Link and Piston Assembly
52 - Screw and Washer
53 - Screw and Washer
54 - Cover
55 - Diaphragm Spring
56 - Diaphragm Assembly
57 - Screw and Washer
58 - Secondary Housing
59 - Retainer
60 - Gasket
61 - Lock Screw
62 - Gasket
63 - Fuel Level Adjusting Nut
64 - Fuel Inlet Needle and Seat
65 - "O" Ring Seal
66 - Screw
67 - Gasket
68 - Primary Fuel Bowl
69 - Gasket
70 - Fuel Inlet Fitting
71 - Diaphragm Spring
72 - Diaphragm Assembly
73 - Accelerating Pump Cover
74 - Retaining Screw and Lockwasher
75 - Gasket
76 - Fuel Level Sight Plug
77 - Baffle Plate
78 - Float
79 - Retainer
80 - Float Spring
81 - Primary Fuel Bowl Gasket
82 - Idle Adjusting Needle
83 - Main Jet
84 - Seal
85 - Baffle Plate
86 - Main Jet
87 - Primary Metering Block
88 - Seal
89 - Idle Adjusting Needle
90 - Primary Metering Block Gasket
91 - Power Valve Gasket
92 - Power Valve
93 - Gasket
94 - Secondary Plate
95 - Metering Body Gasket
96 - Secondary Metering Body
97 - Screw, Clutch
98 - Retainer
99 - "O" Ring Seal
100 - Fuel Distribution Tube
101 - Spring
102 - Float
103 - "O" Ring Seal
104 - Baffle Plate
105 - Secondary Fuel Bowl
106 - Screw
107 - Gasket
108 - Gasket
109 - Fuel Level Sight Plug
110 - "O" Ring Seal
111 - Fuel Inlet Needle and Seat
112 - Fuel Level Adjusting Nut
113 - Gasket
114 - Lock Screw

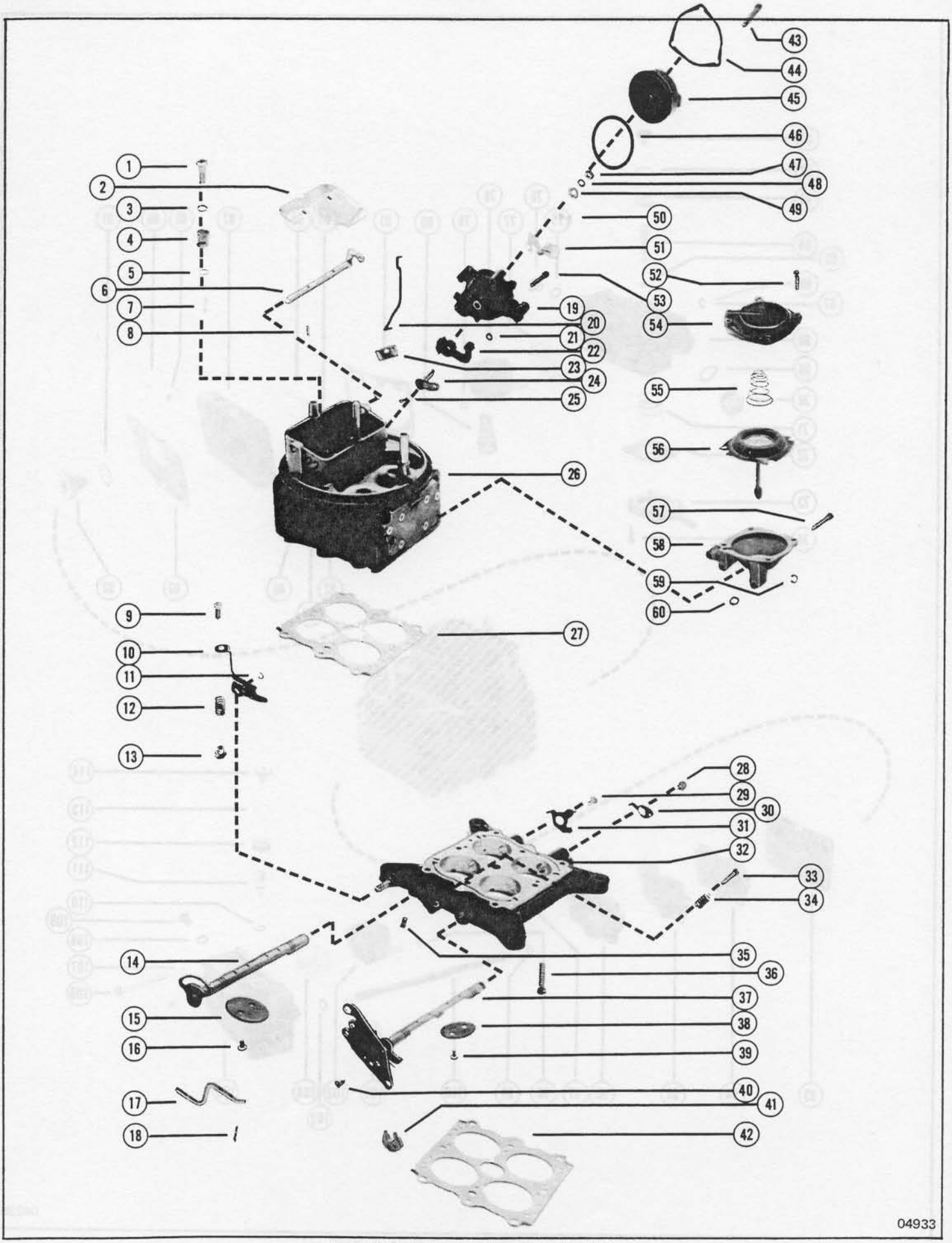

Figure 2. Holley Carburetor Exploded View

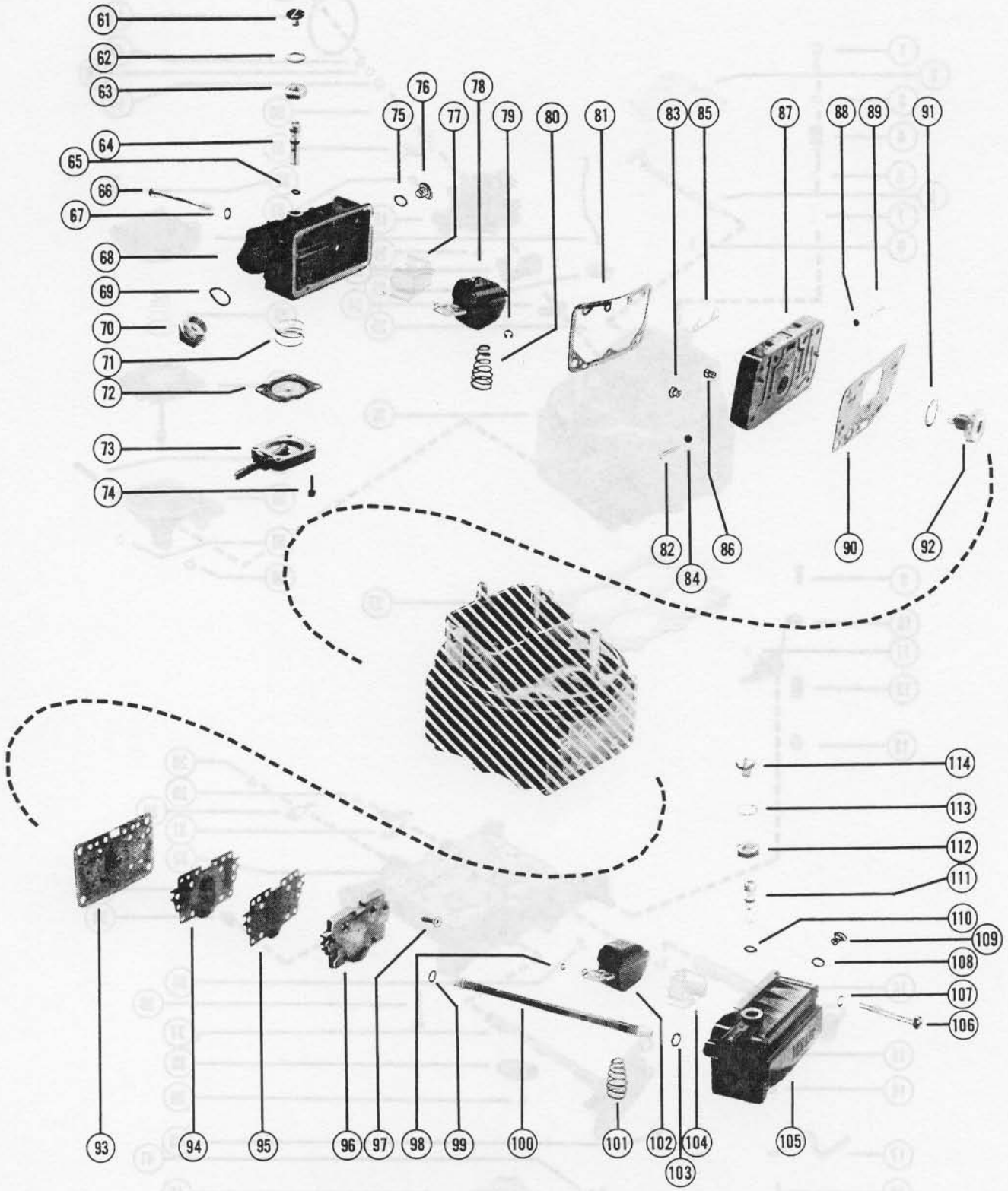

Figure 3. Holley Carburetor Exploded View

DISASSEMBLY

To facilitate working on carburetor and to prevent damage to throttle plates, install carburetor base on repair stand. (Figure 7) If repair stand is not available, install 4 bolts (about 2¼" [57.2mm] long of correct diameter) and 8 nuts on carburetor base. Use separate container for component parts of various assemblies for easier cleaning, inspection and reassembly.

Following is a step-by-step sequence of operations for completely overhauling the carburetor. However, certain carburetor components may be serviced without a complete disassembly. For complete carburetor overhaul, follow all steps. For partial overhaul or to install a new gasket kit, follow only the applicable steps.

Refer to Figures 2 and 3 for identification of parts used on Holley Carburetor.

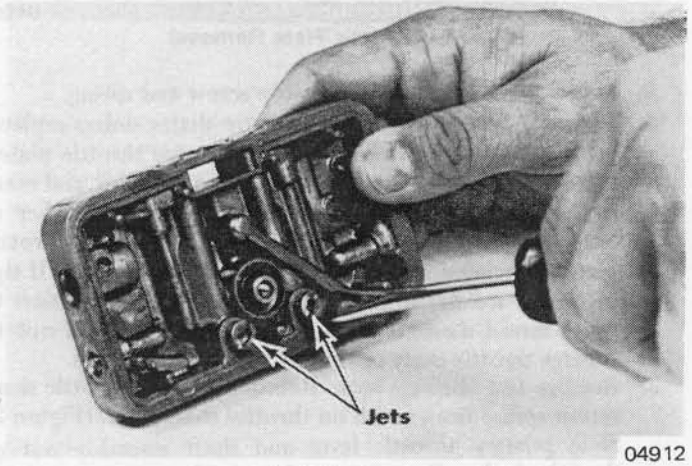

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Figure 4. Main Jet Removal

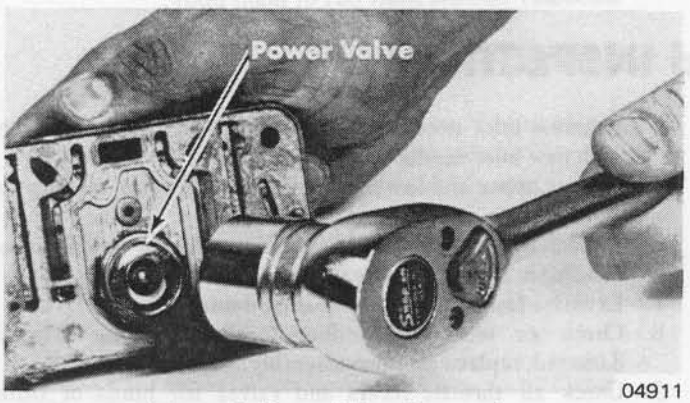

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Figure 5. Power Valve Removal

PRIMARY FUEL BOWL and METERING BLOCK DISASSEMBLY

Refer to Figures 2 and 3 for correct location of fuel bowl parts.

1. Remove fuel bowl and gasket and metering block and gasket. Discard gaskets.
2. Remove fuel line tube and discard "O" ring seal.
3. Remove fuel distribution tube, washer and "O" ring seal. Discard "O" ring seal.
4. Remove idle adjusting needles and gaskets. Discard gaskets.
5. Remove main jets with screwdriver. (Figure 4)

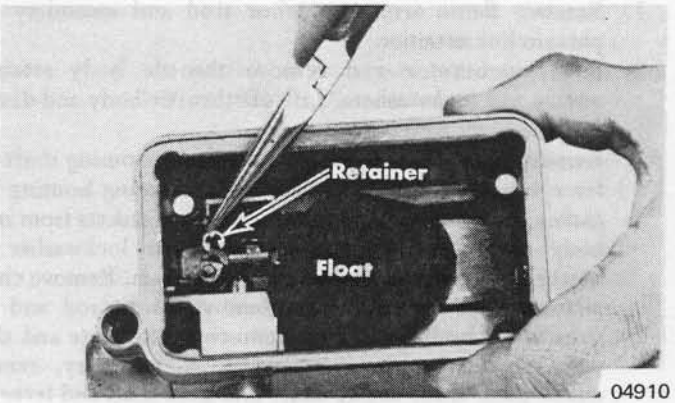

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Figure 6. Float Shaft Retainer Removal

6. Remove power valve and gasket with socket wrench. (Figure 5)
7. Remove fuel level adjustment lock screw and gasket. Turn adjusting nut counterclockwise and remove locknut and gasket. Remove fuel inlet needle and seat assembly. Do not disassemble fuel inlet needle and seat. They are matched assemblies and are replaced as an assembly.
8. Remove float retainer with needle-nose pliers. (Figure 6) Slide float off shaft. Remove spring from float.
9. Remove baffle plate from fuel bowl.
10. Remove fuel level sight plug and gasket.
11. Remove fuel inlet fitting and gasket.
12. Invert fuel bowl and remove accelerating pump cover, diaphragm and spring. Accelerating pump inlet ball check is not removable.

SECONDARY FUEL BOWL and METERING BODY DISASSEMBLY

1. Remove fuel bowl. Using clutch-type screwdriver, remove metering body, plate and gaskets. (Figure 7)
2. Disassemble fuel bowl by following Steps 7-thru-10 under "Primary Fuel Bowl and Metering Block Disassembly", immediately preceding.

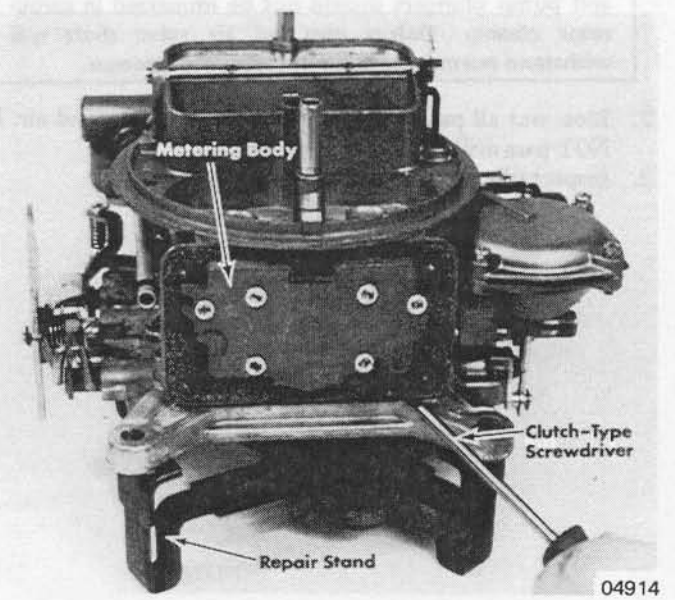

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Figure 7. Secondary Metering Body Removal

MAIN BODY DISASSEMBLY

1. Remove flame arrestor anchor stud and secondary diaphragm link retainer.
2. Invert carburetor and remove throttle body retaining screws and lockwashers. Lift off throttle body and discard throttle body gasket.
3. Remove choke rod retainer from choke housing shaft and lever assembly. Remove thermostatic spring housing and gasket, then remove choke housing and gaskets from main body. Remove choke housing shaft nut, lockwasher and spacer, then remove shaft and fast idle cam. Remove choke piston and lever assembly. Remove choke rod and seal from main body. DO NOT remove choke plate and shaft unless replacement is necessary. If necessary, remove choke plate from choke shaft and slide shaft and lever out of air horn. Retaining screws are staked to choke shaft. If tips of screws are flared excessively, file off flared portion to avoid damage to threads in choke shaft. Be careful not to damage choke shaft or venturi while filing screws.
4. Remove secondary diaphragm housing and gasket from main body. Housing must be removed before cover can be removed. Remove diaphragm housing cover, then remove spring and diaphragm from housing.
5. Remove accelerating pump discharge nozzle screw and lift pump discharge nozzle and gaskets out of main body. Invert main body to allow accelerating pump discharge needle to drop out into hand.

THROTTLE BODY DISASSEMBLY

1. Remove accelerating pump operating lever retainer.
2. Remove secondary throttle connecting rod retainers and connecting rod. Remove secondary diaphragm lever and fast idle cam lever retaining screws and washers. Remove levers.

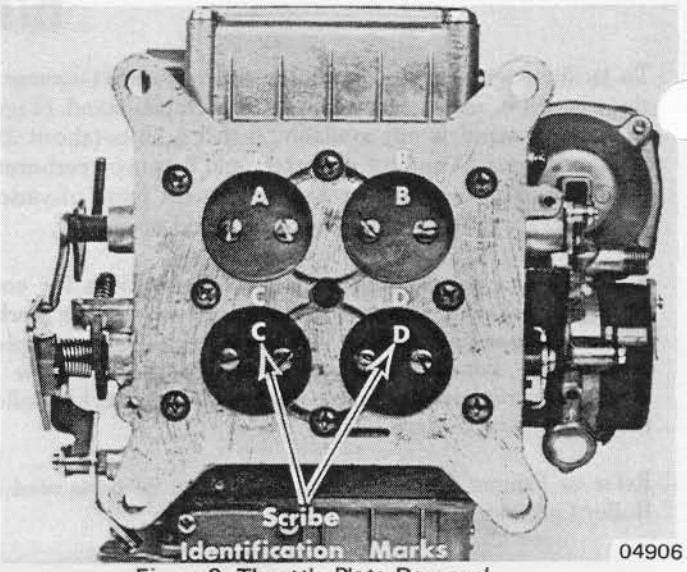

Figure 8. Throttle Plate Removal

3. If necessary, remove throttle stop screw and spring.
4. DO NOT remove throttle plates or shafts unless replacement is necessary. If necessary to remove throttle plates, lightly scribe throttle plates along throttle shaft and mark each plate and its corresponding bore with a number or letter for proper installation. (Figure 8) Remove throttle plates. Retaining screws are staked to throttle shaft. If tips of screws are flared excessively, file off flared portion to avoid thread damage in throttle shaft. Be careful not to damage throttle shaft or venturi while filing screws.
5. Remove fast idle cam lever. Remove primary throttle shaft return spring from notch on throttle shaft lever. (Figure 2) Slide primary throttle lever and shaft assembly out of throttle body. Remove accelerating pump cam. Slide secondary throttle shaft out of main body.

CLEANING and INSPECTION

1. Clean carburetor in a cold immersion-type cleaner, such as Carbon-X (X-55) or its equivalent.

CAUTION: Any rubber parts, plastic parts, diaphragms and pump plungers should not be immersed in carburetor cleaner. Delrin cam on air valve shaft will withstand normal cleaning in carburetor cleaner.

2. Blow out all passages in castings with compressed air. DO NOT pass drills thru jets or passages.
3. Inspect idle mixture needles for damage.
4. Examine inlet needle and seat for wear. If worn, replace with new inlet needle and seat assembly.
5. Inspect upper and lower surfaces of carburetor castings for damage.
6. Inspect holes in levers for excessive wear or out-of-round condition. If worn, replace levers.
7. Examine fast idle cam for wear or damage.
8. Check air valve for binding condition. If air valve is damaged, replace air horn assembly.
9. Check all throttle levers and valves for binds or other damage.

REASSEMBLY

Make sure that all holes in new gaskets are properly punched and that no foreign material adheres to gaskets. Be certain that accelerating pump and secondary operating diaphragms are not cut or torn.

Carburetor assembly is shown in Figures 2 and 3.

THROTTLE BODY REASSEMBLY

Refer to Figure 9 for correct location of parts.

1. If secondary throttle plates are removed, slide shaft into throttle body. Refer to lines scribed on throttle plates, then install plates in proper location with screws snug but not tight. Close throttle plates and hold throttle body up to the light. Little or no light should be visible between throttle plates and throttle bores. If throttle plates are properly installed and no binding exists when throttle shaft is rotated, tighten throttle plate screws. Stake screws by supporting shaft and plates on block of wood or soft metal bar to prevent shaft from bending.
   Refer to "Adjustments", following, for correct adjustment of secondary throttle plates.
2. Install secondary diaphragm lever, lockwasher and screw. Be careful not to tear diaphragm stats while installing screws.
3. If primary throttle plates were removed, place accelerating pump cam on primary throttle shaft. Place end of throttle connecting rod with smallest bend in position in primary throttle lever. Slide throttle shaft into throttle body, guiding throttle connecting rod so that other end fits into secondary throttle lever.
4. Position primary throttle return spring so that small tang fits into slot in throttle lever and long tang rests against throttle body stop. (Figure 9)
5. Secure end of connecting rod with pin retainer.
6. Install primary throttle plates with same procedures used for secondary throttle plates.
7. Install fast idle cam lever, lockwasher and screw.
8. Install throttle stop screw and spring.
9. Install accelerating pump operating lever and retainer.

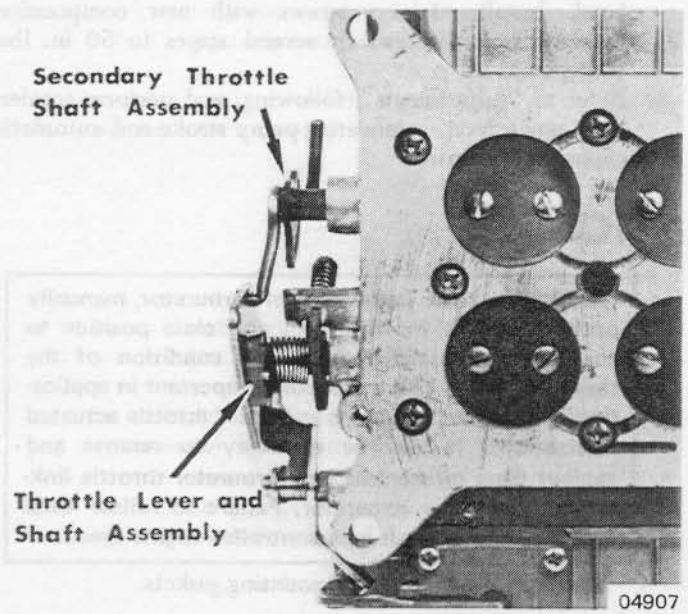

Figure 9. Throttle Lever and Shaft Assembly Installation

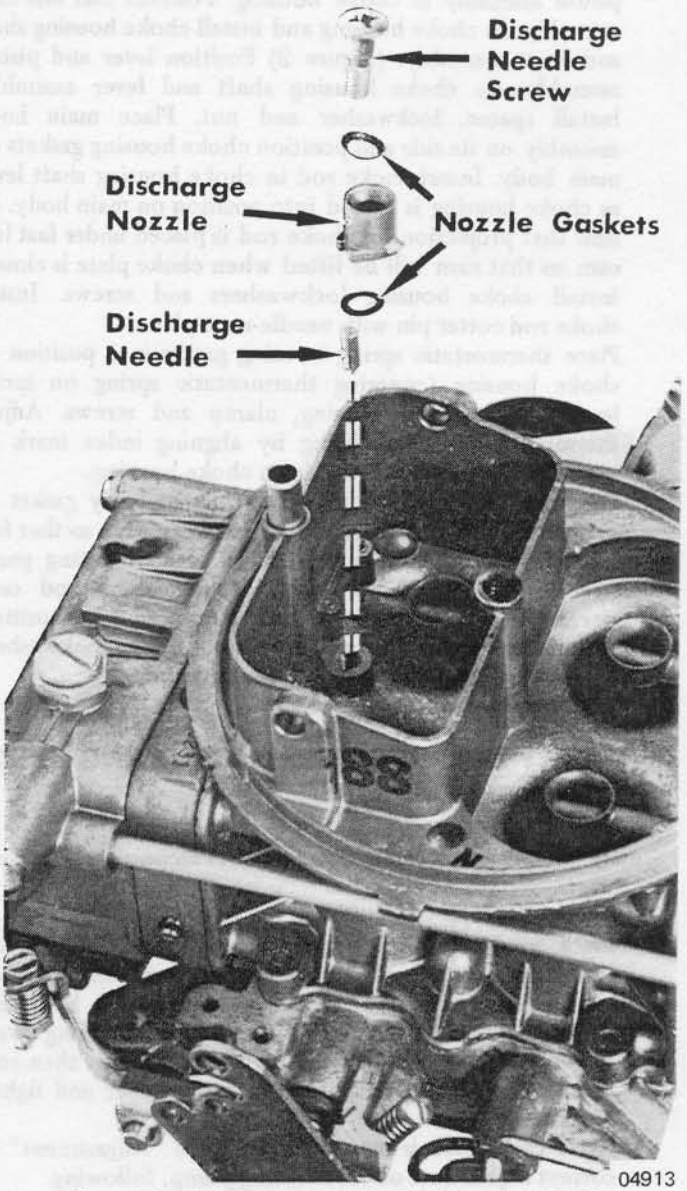

Figure 10. Accelerating Pump Discharge Assembly

MAIN BODY REASSEMBLY

1. Drop accelerator pump discharge needle into its well. (Figure 10) Lightly seat needle with brass drift and hammer. Position accelerating pump nozzle and gaskets in main body and install retaining screw.
2. Secondary diaphragm housing must be installed before choke housing. Position secondary diaphragm in housing and place spring in cover. (Figure 2) Install cover and tighten retaining screws finger-tight. Pull diaphragm rod downward to maximum travel and tighten cover screws. Diaphragm housing must be removed from main body to install cover.
3. Place gasket on secondary vacuum passage opening on main body. Place diaphragm housing in position on main body and install lockwashers and retaining screws.
4. Install rod seal on choke rod. If removed, position choke plate shaft in air horn and install choke plate in shaft. (Figure 2) Slide U-shaped end of choke plate rod thru opening in main body and insert rod end thru inner side of bore in choke lever. Rod end must face outward. Push rod

seal into retaining grooves on underside of flame arrestor mounting flange. Position choke thermostat lever link and piston assembly in choke housing. Position fast idle cam assembly on choke housing and install choke housing shaft and lever assembly. (Figure 2) Position lever and piston assembly on choke housing shaft and lever assembly. Install spacer, lockwasher and nut. Place main body assembly on its side and position choke housing gaskets on main body. Insert choke rod in choke housing shaft lever as choke housing is placed into position on main body. Be sure that projection on choke rod is placed under fast idle cam so that cam will be lifted when choke plate is closed. Install choke housing lockwashers and screws. Install choke rod cotter pin with needle-nose pliers.

Place thermostatic spring housing gasket into position on choke housing (engaging thermostatic spring on spring lever), then install housing, clamp and screws. Adjust thermostatic spring housing by aligning index mark on cover with mid-position mark on choke housing.

5. Invert main body and position throttle body gasket on main body. Place throttle body on main body so that fuel inlet fitting will be on same side as accelerating pump operating lever. Slide secondary diaphragm rod onto operating lever as throttle body is placed into position. Install throttle body to main body screws and lockwashers. Secure secondary diaphragm rod with retainer.
6. Install flame arrestor anchor stud.

PRIMARY FUEL BOWL and METERING BLOCK REASSEMBLY

Refer to Figures 2 and 3 for correct location of fuel bowl parts.

1. Place accelerating pump diaphragm spring and diaphragm in accelerating pump chamber. Diaphragm must be positioned so that large end of lever disc will be against operating lever. Install cover and tighten retaining screws finger-tight. Make sure diaphragm is centered, then compress diaphragm with pump operating lever and tighten cover screws.

   After carburetor is assembled, refer to "Adjustment" for correct adjustment of accelerating pump, following.
2. Install gasket and fuel inlet fitting.
3. Install fuel level sight plug and gasket.
4. Slide baffle plate onto ridges in fuel bowl.
5. Install float spring on float and slide float onto shaft. Be sure that float spring is between ridges on boss on floor of fuel bowl. Install float retainer with needle-nose pliers.
6. Apply petroleum jelly to new "O" ring seal and slide on fuel inlet needle and seat assembly.
7. Position fuel inlet needle and seat assembly in fuel bowl thru top of bowl. Position adjusting nut gasket and nut o fuel inlet needle and seat assembly. Align flat on ID of nu with flat on OD of fuel inlet needle and seat assembly. Install fuel level adjustment lock screw and gasket.
8. As a preliminary float adjustment, refer to "Adjustments", following, and perform "Float Level Adjustment (Dry)" procedure.
9. Install power valve and gasket in metering block with socket wrench. (Figure 5) Be sure to install correct power valve. Refer to specifications for correct identification number (stamped on flat on base of valve).
10. Install jets in metering block with screwdriver. (Figure 4)
11. Install idle adjusting needles and new gaskets. Turn idle adjusting needles in until they just touch the seat, then back needles off the specified number of turns for a preliminary idle adjustment.
12. Position metering block gasket on dowels (located on back of metering block). Position metering block and gasket on main body. Position baffle plate (primary side only) and gasket on metering block. Place retaining screws and new compression gaskets in fuel bowl. Position bowl in place on metering block and tighten retaining screws.
13. Apply petroleum jelly to fuel distribution tube "O" ring seal. Place seal on one end of fuel line tube. Install this end of fuel line tube into recess in primary fuel bowl.

SECONDARY FUEL BOWL and METERING BOWL REASSEMBLY

1. Assemble secondary fuel bowl and perform float adjustment (dry) by following Steps 3-thru-8 under "Primary Fuel Bowl and Metering Block Reassembly", preceding in this section.
2. Slide metering body gasket (Figure 3) into position on main body. Position metering plate gasket, metering plate, gasket and metering body on main body and install retaining screws. (Figure 7)
3. Apply petroleum jelly to fuel line tube "O" ring seal and position seal on end of fuel distribution tube. Position fuel bowl on main body, guiding fuel line tube into recess in bowl. Install retaining screws with new compression gaskets. Torque screws in several stages to 50 in. lbs. (58kg-cm).
4. Refer to "Adjustments", following, and perform accelerating pump lever, accelerating pump stroke and automatic choke adjustments.

INSTALLATION

1. Be sure all old gasket material is removed from manifold and carburetor mounting surfaces. Place new carburetor mounting gasket on manifold.
2. Position carburetor on intake manifold. Connect choke heat wires to carburetor. Install carburetor retaining nuts and tighten evenly and alternately to specifications.
3. Tighten choke heat tube fitting at carburetor. Install new retaining clamp on fuel inlet hose. Install hose on fuel inlet fitting. Tighten retaining clamp.
4. Adjust engine idle speed and idle fuel mixture. Refer to "Adjustments", following, for proper procedure.

WARNING: After installation of carburetor, manually operate throttle for full open and close position to check for a binding or sticking condition of the throttle linkage. This is especially important in applications that include dashpots and other throttle actuated mechanisms. It may be necessary to remove and replace these mechanisms and carburetor throttle linkage parts on this carburetor. Failure to follow these procedures may result in uncontrolled engine speed.

5. Install flame arrestor with mounting gaskets.

ADJUSTMENTS

Fuel level float adjustment (dry) and secondary throttle plate adjustment are performed only as bench adjustments. Preliminary idle fuel mixture and idle speed adjustments, automatic choke adjustment and accelerating pump lever and stroke adjustments can be performed with carburetor on bench or installed on engine.

Fuel lever adjustment, carburetor inter-connecting linkage adjustment, idle fuel mixture and idle speed adjustments are performed only with carburetor installed on engine.

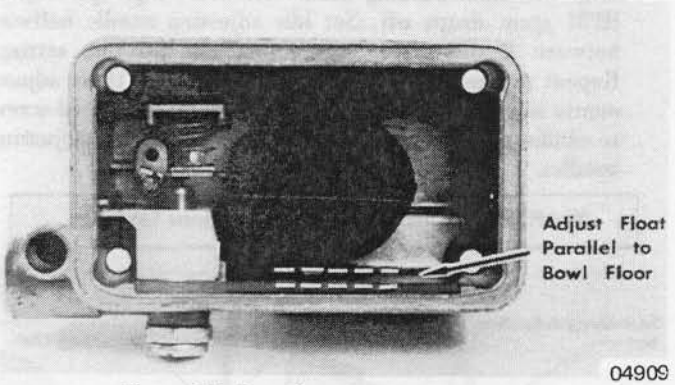

Figure 11. Dry Float Level Adjustment

FLOAT LEVEL ADJUSTMENT (DRY)

With float bowl upside down, adjust float parallel to bowl floor (Figure 11) by loosening lock screw and turning adjusting nut.

SECONDARY THROTTLE STOP SCREW ADJUSTMENT

Back secondary throttle stop screw out until secondary throttle plates are closed in the bore. Turn screw in until it touches the lever, then add ½-turn.

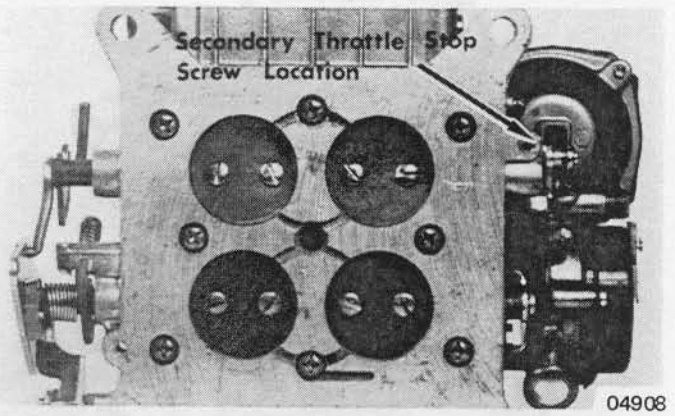

Figure 12. Secondary Throttle Stop Screw Location

ACCELERATOR PUMP LEVER CLEARANCE

1. With throttle valves at wide open throttle and pump lever held down, insert gauge between adjusting nut and operating lever. (Figure 13)
2. Adjust pump over-ride screw until correct clearance is obtained.

NOTE: There must be no free movement of pump leverage when throttle is at idle.

CHOKE UNLOADER ADJUSTMENT

Choke unloader is a mechanical device to partially open choke at wide open throttle. Adjust as follows:

1. Hold throttle valves in wide open position, insert drill between upper edge of choke valve and inner wall of air horn.
2. Press finger lightly against choke control lever. A slight drag should be felt as drill is pulled out. (Figure 14)
3. To adjust, bend tab on kick-down lever until correct opening has been obtained.

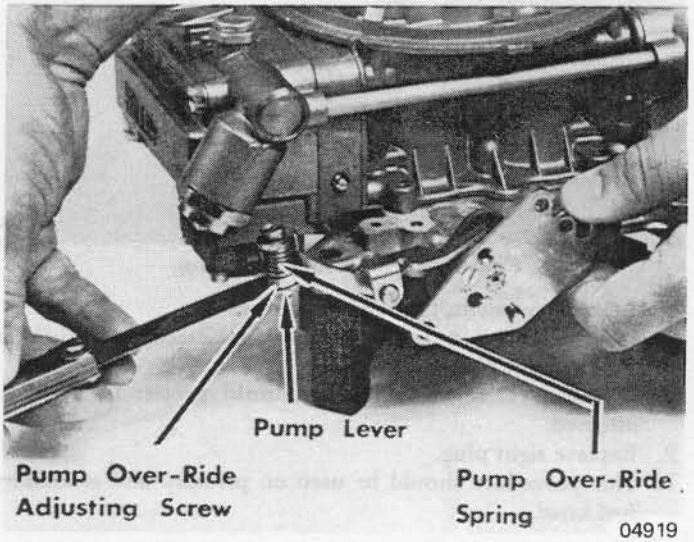

Figure 13. Accelerator Pump Lever Clearance

FLOAT LEVEL ADJUSTMENT (WET)

1. With flame arrestor removed and ignition "off", remove sight plug (Figure 15), then remove bowl lower attaching screw furthest from fuel inlet. (Figure 16)
2. Drain off fuel into a shallow pan, using care not to spill fuel and create a fire hazard.
3. Reinstall fuel bowl screw.

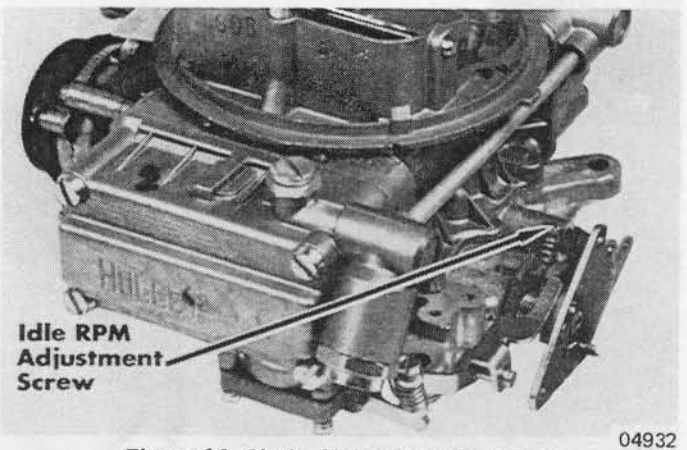

Figure 14. Choke Unloader Adjustment

4. With engine running, fuel level should be on line with threads at bottom of sight plug port (plus-or-minus 1/32" [.8mm] tolerance).
5. To correct fuel level, loosen lock screw (Figure 17) and turn adjusting nut clockwise to lower fuel level and counterclockwise to raise fuel level (1/6-turn of adjusting nut equals approximately 1/16" [1.6mm] in fuel level).

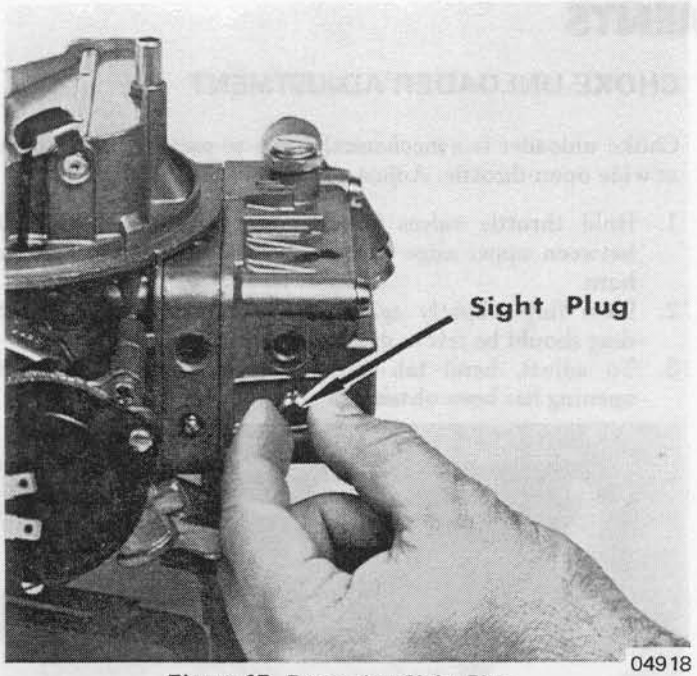

Figure 15. Removing Sight Plug

6. After adjustment, tighten lock screw.
7. Operate engine until fuel level is stabilized, then recheck level at sight plug.
8. If necessary, repeat adjustment until proper fuel level is attained.
9. Replace sight plug.
10. This procedure should be used on primary and secondary fuel bowl.

IDLE SPEED and MIXTURE ADJUSTMENT

1. Adjustment must be made with boat as level as possible.

NOTE: When seating idle adjusting needle, care must be taken not to turn screw tight against seat, thus grooving tip of needle. If needle becomes grooved, a smooth idle cannot be obtained.

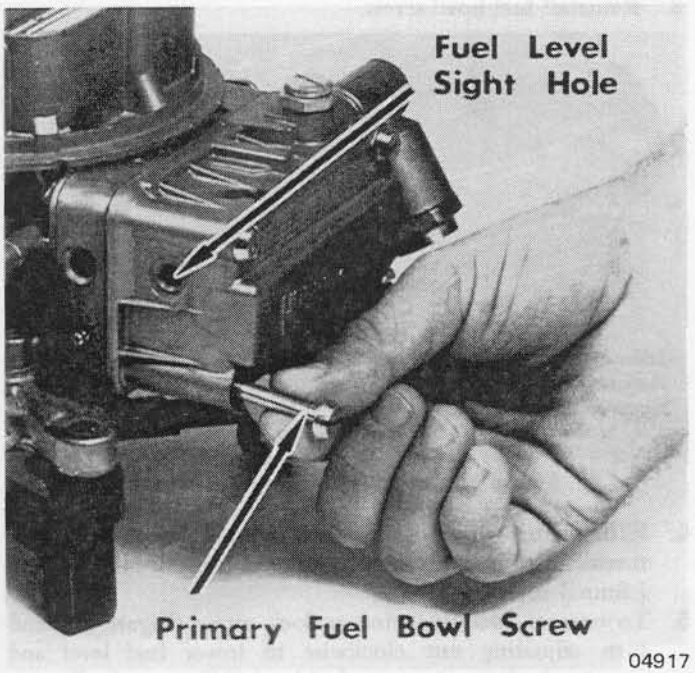

Figure 16. Removing Fuel Bowl Lower Screw

2. Seat idle adjusting needles lightly and back each off a full turn, if there is doubt that this was not done during reassembly. (Figure 18)
3. Start engine and allow operating temperature to reach normal.
4. After engine reaches normal operating temperature, adjust idle speed screw to idle engine at specified RPM.
5. First, set one of the 2 idle adjusting needles for highest steady manifold vacuum reading. If a vacuum gauge is not available, obtain smoothest-running, maximum idle speed by turning idle adjusting needle in until RPM begins to drop off, then backing needle off over "high spot" until RPM again drops off. Set idle adjusting needle halfway between 2 points for satisfactory idle mixture setting. Repeat procedure with other needle. Should these adjustments show an increase in idle RPM, reset idle speed screw to obtain specified idle RPM and again adjust idle adjusting needles.

WARNING: Check all fuel connections for leaks.

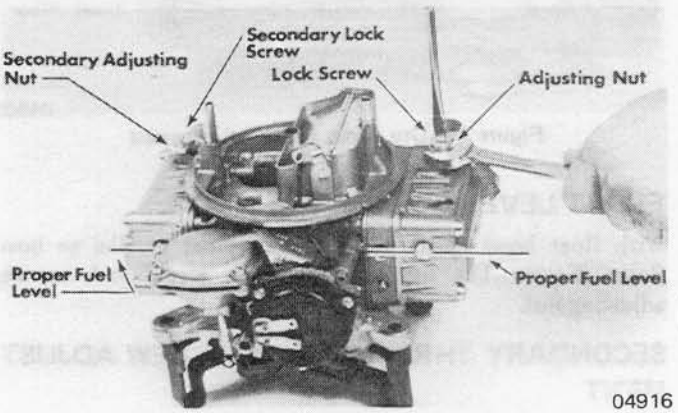

Figure 17. Adjusting Fuel Level

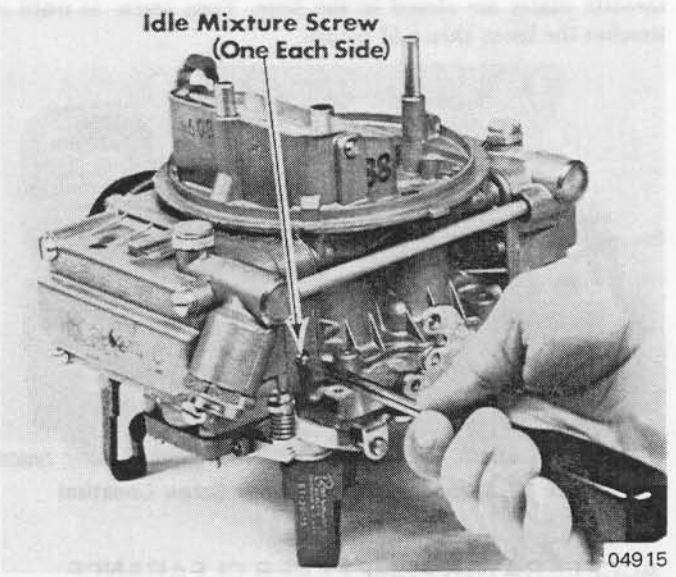

Figure 18. Adjusting Idle Fuel Mixture

AUTOMATIC CHOKE ADJUSTMENT

1. Automatic choke is set accurately at factory to give best possible all-weather operation. To return choke to original setting, line up index mark with proper specification.
2. If, for some reason, a richer or leaner mixture during warm-up period is desired, it can be obtained by rotating thermostat cover. Never set index mark on cover more than 2 graduations off specified settings.

MODEL 4MV and 4MY QUADRAJET CARBURETORS

DESCRIPTION

The model 4MV Quadrajet is a 4-barrel, 2-stage carburetor. (Figure 1)

The Quadrajet carburetor has 2 stages in operation. The primary (fuel inlet) side has small bores with a triple venturi set-up equipped with plain tube nozzles. Its metering principles are similar to most plain tube carburetors which use the venturi principle. The triple venturi stack up, plus smaller primary bores, give a more stable and finer fuel control in idle and economy ranges of operation. Fuel metering in primary side is accomplished with tapered metering rods positioned by a manifold vacuum responsive piston.

Secondary side has 2 very large bores which have greatly increased air capacity to meet present day and future automotive engine demands. Air valve principle is used in secondary side for metering control and supplements fuel flow from primary bores.

Using air valve principle, fuel is metered in direct proportion to air passing thru secondary bores.

Fuel reservoir is centrally located to avoid problems of fuel slosh causing engine turn cut-out and delayed fuel to carburetor bores. Float system uses a single float pontoon for ease in servicing the unit.

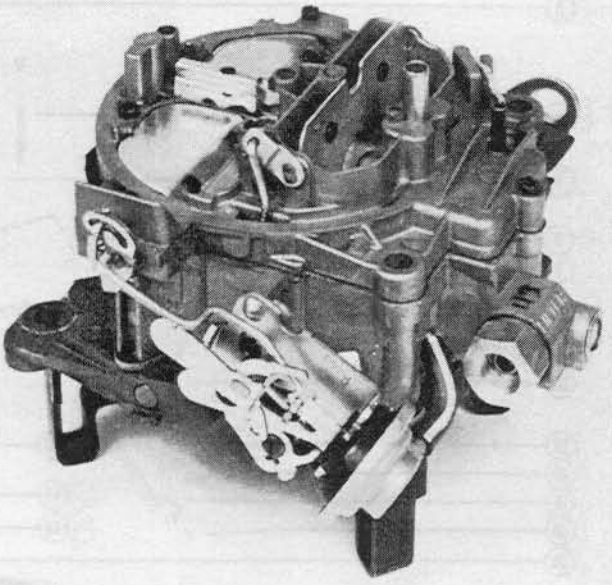

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Figure 1. 4MV Quadrajet Carburetor

REMOVAL

1. Remove flame arrestor.
2. Disconnect fuel line.
3. Disconnect throttle linkage.
4. Disconnect choke coil rod.
5. Remove fasteners which fasten carburetor to intake manifold and remove carburetor from manifold.
6. Remove and discard carburetor to manifold gasket.

AIR HORN REMOVAL

1. Mount carburetor on suitable holding fixture.
2. Remove clips from upper end of choke rod. Disconnect choke rod from upper choke shaft lever and remove choke rod from bowl. (Figure 2)
3. Remove spring clip from upper end of pump rod and disconnect pump rod from pump lever. (Figure 2)
4. Remove 9 air horn to bowl attaching screws (4 long screws, 3 short screws and 2 counter-sunk screws). (Figure 2) Two attaching screws are located next to primary venturi.
5. Remove air horn by lifting straight up. Air horn gasket should remain on bowl for removal later.

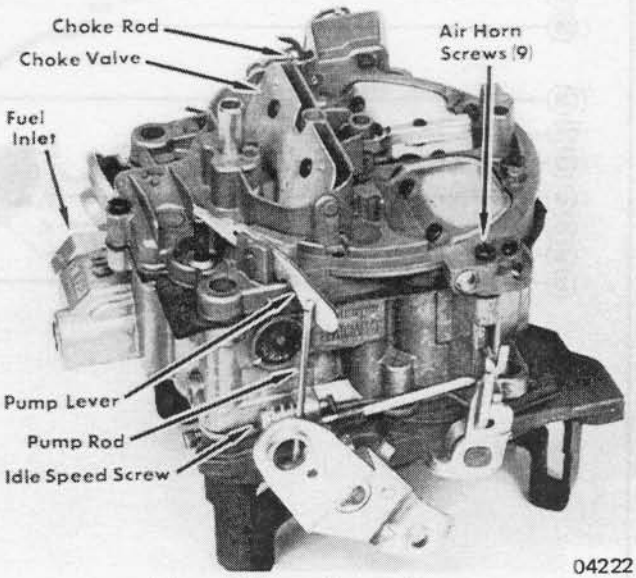

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Figure 2. Removing Air Horn

CAUTION: Care must be taken not to bend 2 small main well air bleed tubes protruding from air horn. These are permanently pressed into casting. DO NOT REMOVE.

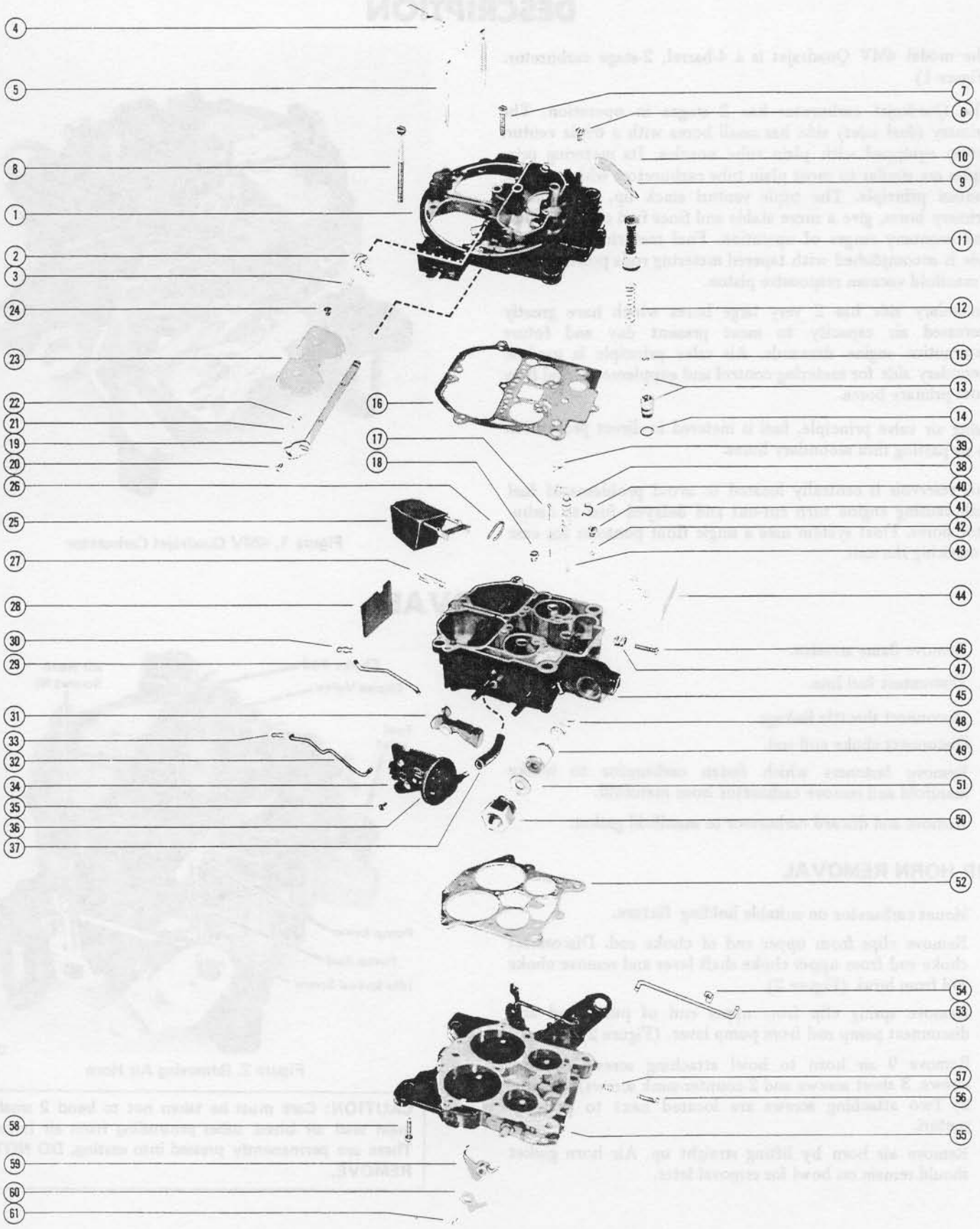


Figure 3. 4MV Quadrajet Carburetor Exploded View

Legend for Figure 3

1 - Air Horn Assembly
2 - Lever, air valve lockout
3 - Roll Pin, lockout lever
4 - Holder Kit, secondary metering rod
5 - Metering Rod, secondary
6 - Screw
7 - Screw
8 - Screw
9 - Lever, actuating - pump
10 - Roll Pin, hinge - pump lever
11 - Pump Assembly
12 - Spring, pump return
13 - Needle and Seat Assembly
14 - Gasket, needle and seat
15 - Pull Clip, float needle
16 - Gasket, air horn
17 - Metering Rod, primary
18 - Jet, primary
19 - Choke Shaft and Lever Assembly
20 - Screw, choke lever attaching
21 - Lockwasher, choke lever screw
22 - Nut, choke lever screw
23 - Valve, choke - choke shaft
24 - Screw, choke valve to choke shaft
25 - Float Assembly
26 - Pin, hinge - float
27 - Lever, intermediate choke
28 - Baffle, float bowl
29 - Rod, choke
30 - Clip, choke rod
31 - Cam, fast idle
32 - Rod, vacuum control
33 - Clip, vacuum control rod
34 - Bracket Assembly, vacuum control
35 - Screw, vacuum control bracket to float bowl
36 - Control Assembly, vacuum
37 - Hose, vacuum
38 - Power Piston Assembly
39 - Spring, metering rod - primary
40 - Retainer, power piston
41 - Retainer, pump discharge ball
42 - Ball, pump discharge
43 - Spring, power piston
44 - Insert, float bowl
45 - Float Bowl Assembly
46 - Screw, idle stop
47 - Spring, idle stop screw
48 - Spring, filter nut
49 - Filter, fuel inlet
50 - Nut, filter - fuel inlet
51 - Gasket, filter nut
52 - Gasket, throttle body
53 - Rod, pump
54 - Clip, pump rod
55 - Throttle Body Assembly
56 - Idle Needle, throttle body
57 - Spring, idle needle
58 - Screw, throttle body to float bowl
59 - Lever, cam
60 - Lever, fast idle
61 - Screw, lever and cam to throttle body

DISASSEMBLY

AIR HORN DISASSEMBLY

1. Remove secondary metering rods by holding air valve wide open, then tilt and slide rods from holes in hanger. (Figure 4)

   NOTE: Further disassembly of air horn is not required for cleaning purposes. If part replacement is required, proceed as follows:

2. Remove choke valve attaching screws, then remove choke valve and shaft.
3. Remove pump lever roll pin, then pump lever.

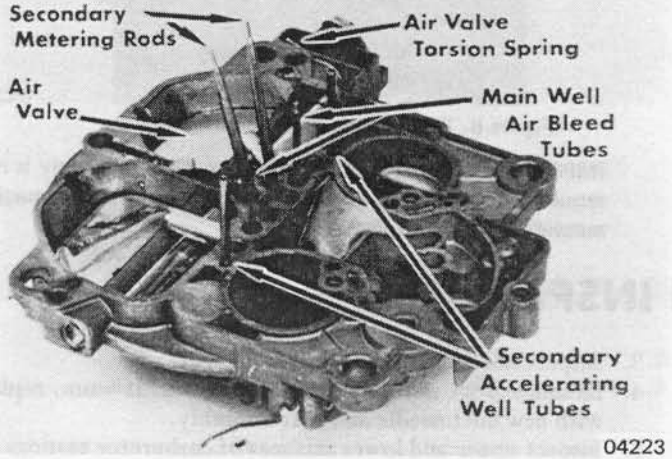


Figure 4. Air Horn Disassembly

CAUTION: Air valves, air valve shaft and secondary metering rod hangers are calibrated and should not be removed.

FLOAT BOWL DISASSEMBLY

1. Remove pump plunger from pump well.
2. Remove air horn gasket from dowels on secondary side of bowl, then remove gasket from around power piston and primary metering rods.

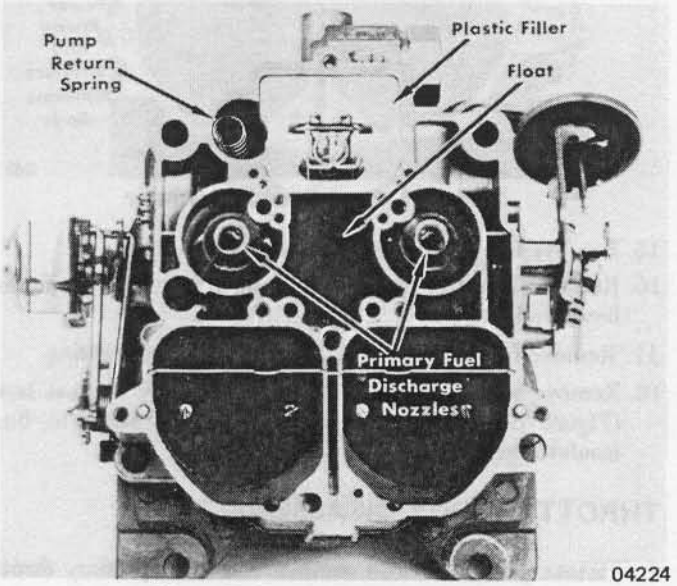


Figure 5. Float Bowl Disassembly

3. Remove pump return spring from pump well. (Figure 5)
4. Remove plastic insert located over float assembly. (Figure 5)
5. Remove power piston and primary metering rods, using needle-nosed pliers to pull straight up on metering rod hanger directly over power piston. Remove power piston spring from well. (Figure 6)
6. Remove metering rods from power piston by disconnecting tension spring from top of each rod, then rotating rod to remove from hanger.
7. Remove float assembly by pulling up slightly on retaining pin until pin can be removed by sliding toward pump well. Lift float and inlet needle up out of float bowl.
8. Remove pull clip from float arm and inlet needle, being careful not to distort clip.
9. Remove fuel inlet needle seat from float bowl with a wide blade screwdriver. Remove gasket from seat.
10. Remove primary metering jets. DO NOT remove secondary metering plates. (Figure 7)
11. Remove pump discharge check ball retainer and check ball. (Figure 7)

12. Remove baffle from secondary side of bowl. (Figure 7)
13. Remove vacuum hose from vacuum break assembly and from tube connection on bowl. (Figure 7)
14. Remove retaining screw from choke assembly and remove assembly from float bowl.

NOTE: If further disassembly of choke is necessary, remove clip from vacuum break link at vacuum break lever, then remove rod from vacuum break lever. Spread retaining ears on bracket next to vacuum break assembly, then remove vacuum break assembly from lever.

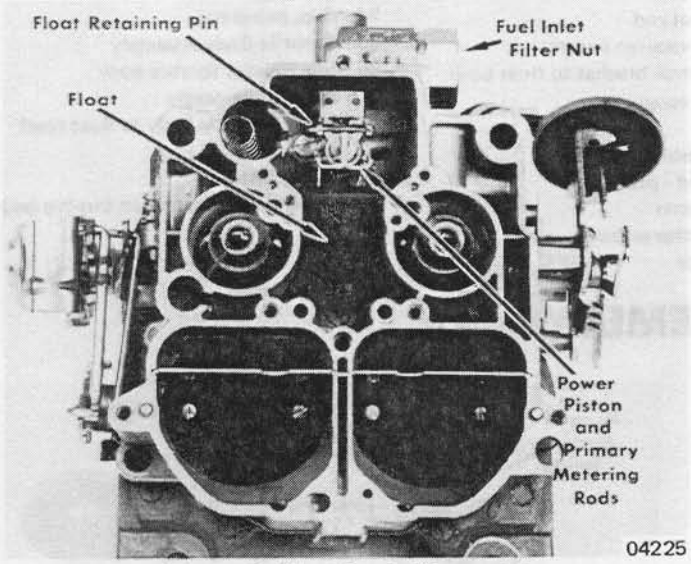


Figure 6. Float Bowl Disassembly

15. Remove fast idle cam from choke assembly.
16. Remove lower choke rod and actuating lever from float bowl well.
17. Remove fuel inlet filter nut, gasket, filter and spring.
18. Remove screws which fasten throttle body to float bowl. (Figure 8) Separate pieces and remove bowl to body insulator gasket.

THROTTLE BODY DISASSEMBLY

1. Rotate pump rod and remove rod from primary throttle lever.
2. Remove idle mixture screws and springs.

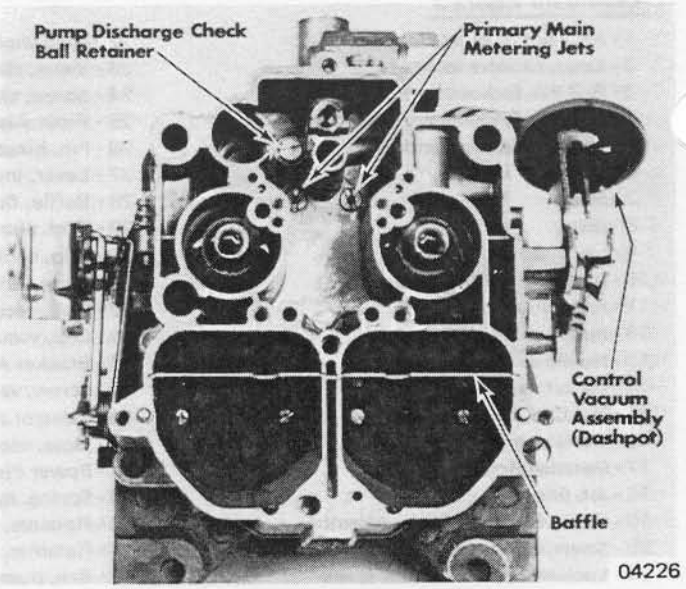


Figure 7. Float Bowl Disassembly

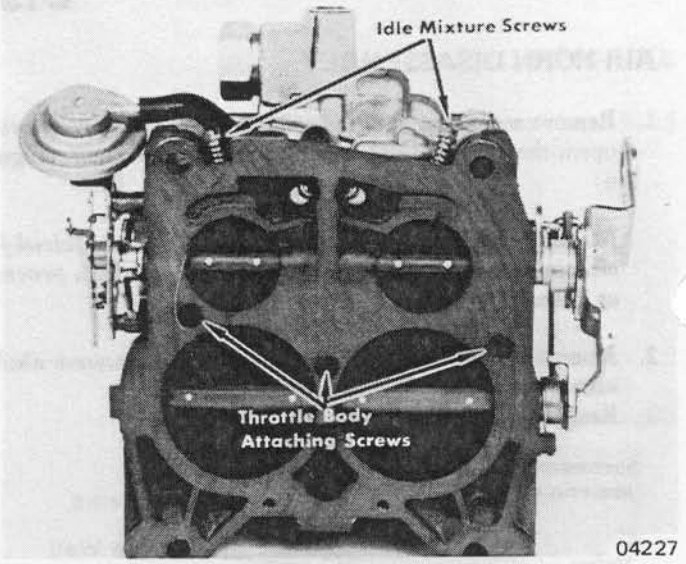


Figure 8. Throttle Body Attaching Screws

IMPORTANT: Further disassembly of throttle body is not required. Extreme care must be taken to avoid damaging secondary throttle valves.

CLEANING and INSPECTION

1. Clean carburetor in a cold immersion-type cleaner, such as Carbon-X (X-55) or equivalent.

CAUTION: Any rubber parts, plastic parts, diaphragms and pump plungers should not be immersed in carburetor cleaner. The delrin cam on air valve shaft, however, will withstand normal cleaning in carburetor cleaner.

2. Blow out all passages in castings with compressed air. Do not pass drills thru jets or passages.
3. Inspect idle mixture needles for damage.
4. Examine float needle and seat for wear. If worn, replace with new inlet needle and seat assembly.
5. Inspect upper and lower surfaces of carburetor castings for damage.
6. Inspect holes in levers for excessive wear or out-of-round condition. If worn, replace levers.
7. Examine fast idle cam for wear or damage.
8. Check air valve for binding condition. If air valve is damaged, replace air horn assembly.
9. Check all throttle levers and valves for binds or other damage.

REASSEMBLY

THROTTLE BODY REASSEMBLY

1. Install idle mixture needles and springs until seated. Back out needles 2 turns as a preliminary idle adjustment.
2. Install pump rod in lower hole of throttle lever by rotating rod.

FLOAT BOWL REASSEMBLY

1. Install new throttle body to bowl insulator gasket. Be certain that gasket is properly installed over 2 locating dowels on bowl.
2. Install throttle body. Be sure that throttle body is properly located over dowels on float bowl, then install throttle body to bowl screws and tighten evenly and securely. Place carburetor on proper holding fixture.
3. Install fuel inlet filter, new gasket and inlet nut and tighten nut securely.

   NOTE: If vacuum break diaphragm was removed from bracket, slide vacuum break diaphragm between retaining ears to hold securely. Install vacuum break rod (U-bend end) in diaphragm link with end toward bracket, then install grooved end of rod in hole of actuating lever and retain to vacuum break lever with spring clip.

4. Install fast idle cam on vacuum break assembly. Be sure that fast idle cam pick-up lever on intermediate choke shaft is located in cut-out area of fast idle cam.
5. Connect choke rod to choke rod actuating lever (plain end). Hold choke rod (with grooved end pointing inward) and position choke rod actuating lever in well of float bowl. Install choke assembly, engaging shaft with hole in actuating lever. Install retaining screw and tighten securely. Remove choke rod from lever for installation later.
6. Install vacuum hose to tube connection on bowl and vacuum break assembly.
7. Install air deflector in secondary side of bowl with notches toward top.
8. Install pump discharge check ball and retainer in passage next to pump well.
9. Install primary main metering jets.
10. Install fuel inlet needle seat and gasket. Use wide blade screwdriver to avoid distortion. Place inlet needle in position in seat.
11. Using needle-nose pliers to hold needle pull clip, install pull clip on needle. Pull clip is properly positioned with open end toward front of bowl.
12. Install float by sliding float lever under pull clip from front to back. With float lever in pull clip, hold float assembly at toe and install retaining pin from pump well side. Be careful not to distort pull clip.
13. Adjust float level as outlined under "Adjustments", following.
14. Install power piston spring in power piston well. If primary main metering rods were removed from hanger, reinstall and make sure that tension spring is connected to top of each metering rod. Install power piston assembly in well with metering rods properly positioned in metering jets. Press down firmly on power piston to ensure engagement of retaining clip.
15. Install plastic insert over float assembly, pressing downward until seated properly.
16. Install pump return spring in pump well.
17. Install air horn gasket around primary metering rods and piston. Position gasket over 2 dowels on secondary side of bowl.
18. Install pump plunger in pump well.

AIR HORN REASSEMBLY

1. Install the following, if removed: Pump lever and retain with roll pin, choke shaft, choke valve and 2 attaching screws.
2. Install secondary metering rods. With air valve held wide open, rods should be positioned with upper ends thru hanger holes and toward each other.

AIR HORN to BOWL INSTALLATION

1. Carefully place air horn assembly on bowl, positioning secondary metering rods, vent tubes and accelerating well tubes thru air horn gasket. When installing, be certain that pump plunger is positioned properly thru air horn. To prevent distortion of secondary metering plates, do not force air horn assembly onto float bowl. A slight sideward movement will center metering rods in metering plates.
2. Install 4 long air horn screws around secondary side, 2 short screws in center section and one short screw above fuel inlet. Two counter-sunk screws are installed in primary venturi area. Tighten all screws evenly and securely. (Figure 9)
3. Connect pump rod to pump lever and retain with spring clip.
4. Connect choke rod to lower choke lever and upper choke lever. Install spring clip on upper end of rod.

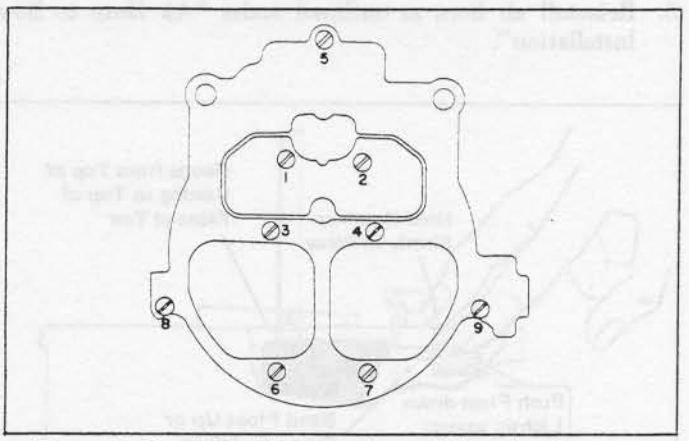


Figure 9. Quadrajet Air Horn Screw Tightening Sequence

5. Connect vacuum break link rod to air valve lever and vacuum break stem. Install spring clip in groove on vacuum break end of link rod.
6. Check following adjustments as outlined:
   a. Pump adjustment.
   b. Choke rod adjustment.
   c. Air valve dashpot adjustment.
   d. Vacuum break adjustment.
   e. Unloader adjustment.
   f. Air valve lockout adjustment.
   g. Secondary opening adjustment.
   h. Secondary closing adjustment.
   i. Secondary metering rod adjustment.
   j. Air valve spring adjustment.

INSTALLATION

1. Place baffle plate and new base gasket in position on intake manifold.
2. Fasten carburetor to manifold, using fasteners which were removed previously.
3. Connect throttle linkage.
4. Connect fuel line.
5. Adjust choke.
6. Install flame arrestor.
7. Adjust idle speed and mixture.

WARNING: After installation of carburetor, manually operate throttle for full open and close position to check for a binding or sticking condition of the throttle linkage. This is especially important in applications that include dashpots and other throttle actuated mechanisms. It may be necessary to remove and replace these mechanisms and carburetor throttle linkage parts on this carburetor. Failure to follow these procedures may result in uncontrolled engine speed.

ADJUSTMENTS

Following adjustments can be completed with carburetor installed on engine. Make adjustments in sequence listed. Adjustment specifications follow.

FLOAT LEVEL (Figure 10)

1. Remove flame arrestor from carburetor.
2. Remove air horn from float bowl as outlined under "Disassembly", preceding.
3. Measure from top of float bowl gasket surface (gasket removed) to top of float at toe (locate gauging point 1/16" [1.6mm] back from toe). Do not gauge on numbers on float.

NOTE: Make sure that retaining pin is held firmly in place and that float tang is seated on float needle.

4. Bend float arm up or down, as required, to obtain dimension specified.
5. Reinstall air horn as outlined under "Air Horn to Bowl Installation".

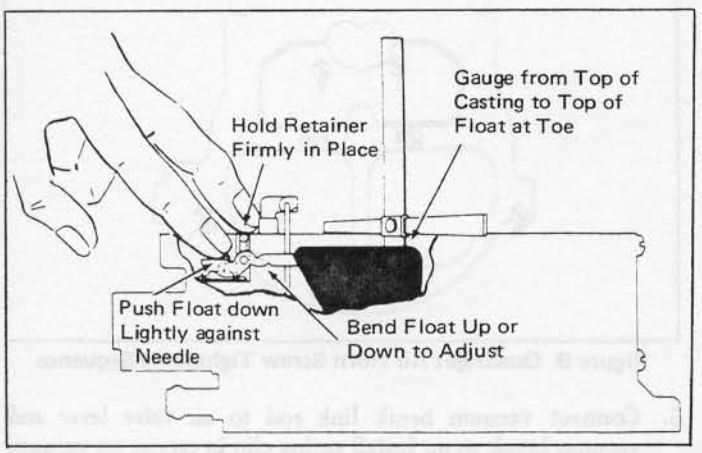


Figure 10. Float Level Adjustment

PUMP ADJUSTMENT (Figure 11)

1. Disconnect secondary actuating link.
2. With throttle valves completely closed and pump rod in specified hole in lever, measure from top of choke valve wall (next to vent stack) to top of pump stem.
3. Bend pump lever to obtain dimensions specified.
4. Connect actuating link.

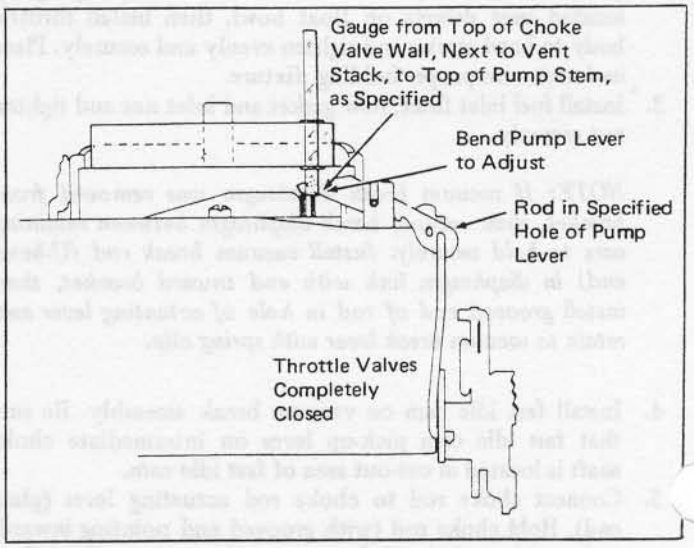


Figure 11. Pump Adjustment

CHOKE ROD ADJUSTMENT (Figure 12)

1. Place cam follower on second step of fast idle cam and against high step. Rotate choke valve toward closed position by pushing down lightly on vacuum break lever.
2. Dimension between lower edge of choke valve and air horn wall should be as specified. Bend choke rod to adjust.

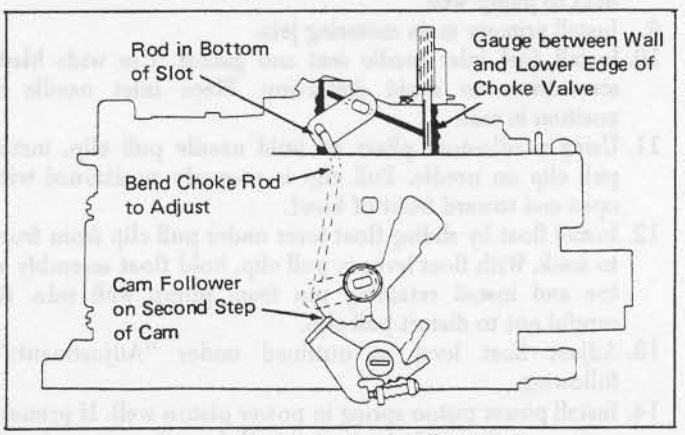


Figure 12. Choke Rod Adjustment

AIR VALVE DASHPOT ADJUSTMENT (Figure 13)

Push vacuum break stem in until diaphragm is seated. Clearance, as specified, must exist between dashpot rod and end of slot in air valve lever. Bend rod at air valve end to adjust.

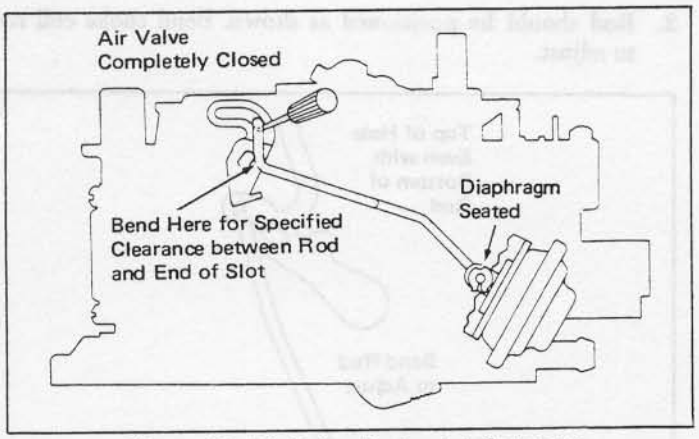


Figure 13. Air Valve Dashpot Adjustment

VACUUM BREAK ADJUSTMENT (Figure 14)

1. Push vacuum break stem in until diaphragm is seated and hold choke valve toward closed position.
2. Dimension between lower edge of choke valve and air horn wall should be as specified. Bend vacuum break tang to adjust.

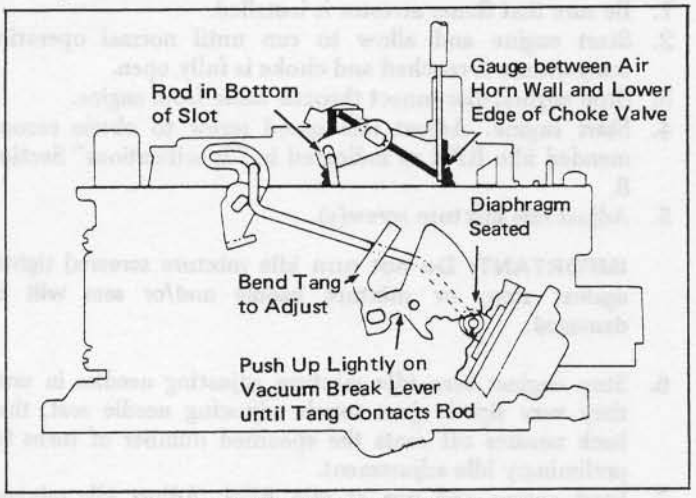


Figure 14. Vacuum Break Adjustment

UNLOADER ADJUSTMENT (Figure 15)

1. With choke valve held in closed position by a rubber band on vacuum break lever, open primary throttle valves to wide open position.
2. Dimension between edge of choke valve and air horn wall should be as specified. Bend fast idle lever tang to adjust.

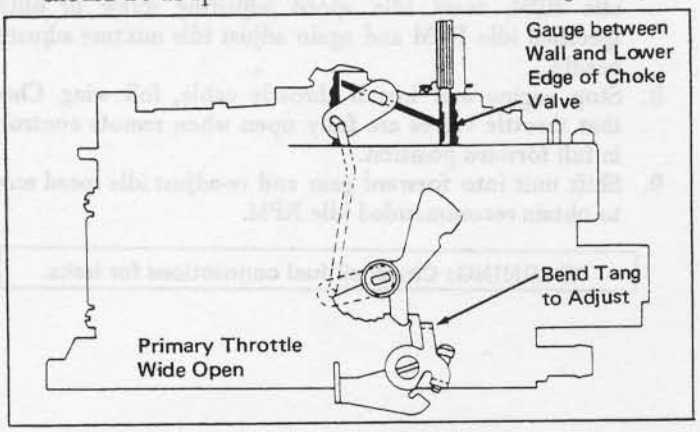


Figure 15. Unloader Adjustment

AIR VALVE LOCKOUT ADJUSTMENT (Figure 16)

1. Open choke valve to wide open position by rotating vacuum break lever. Choke rod must be to top of slot in choke lever.
2. Dimension between front edge of air valve and lockout lever tang must be as specified. Bend upper end of lockout lever tang to adjust.

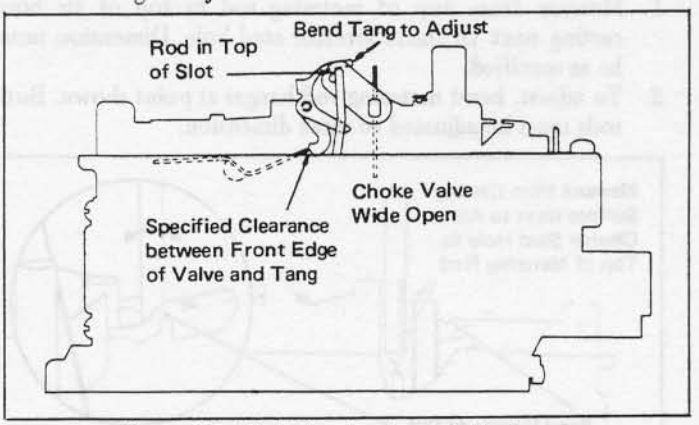


Figure 16. Air Valve Lockout Adjustment

SECONDARY OPENING ADJUSTMENT (Figure 17)

1. Open primary throttle valves until actuating link contacts tang on secondary lever. With valves in this position, dimension between link and tag on secondary lever should be as specified.
2. Bend tang on secondary lever to adjust.

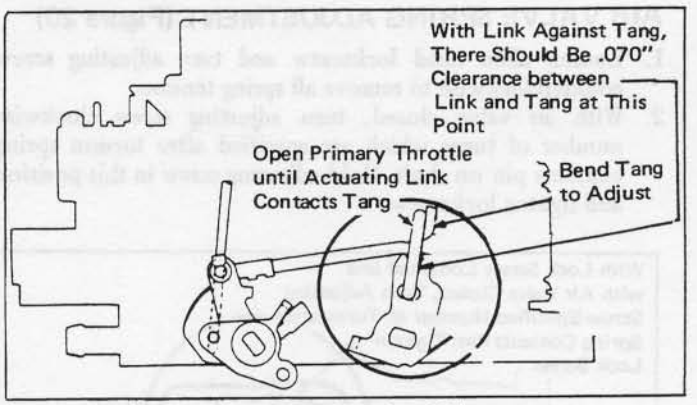


Figure 17. Secondary Opening Adjustment

SECONDARY CLOSING ADJUSTMENT (Figure 18)

1. Set idle speed screw to recommended RPM.
2. Dimension between actuating link and front of slot in

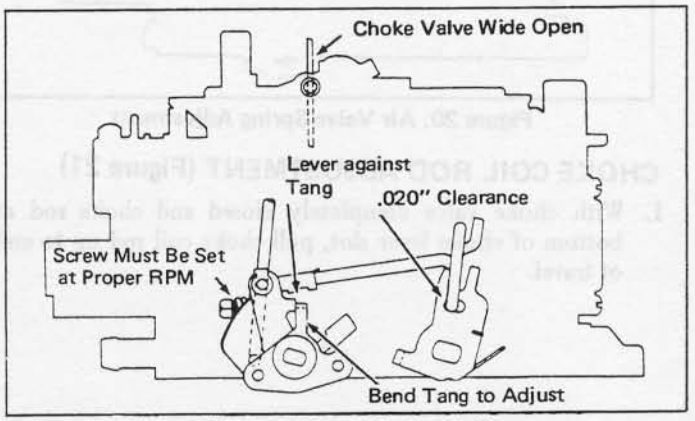


Figure 18. Secondary Closing Adjustment

secondary lever should be as specified when tang on throttle lever is against actuating lever.
3. Bend tang on throttle lever to adjust.

SECONDARY METERING ROD ADJUSTMENT (Figure 19)

1. Measure from top of metering rod to top of air horn casting next to flame arrestor stud hole. Dimension must be as specified.
2. To adjust, bend metering rod hanger at point shown. Both rods must be adjusted to same dimension.

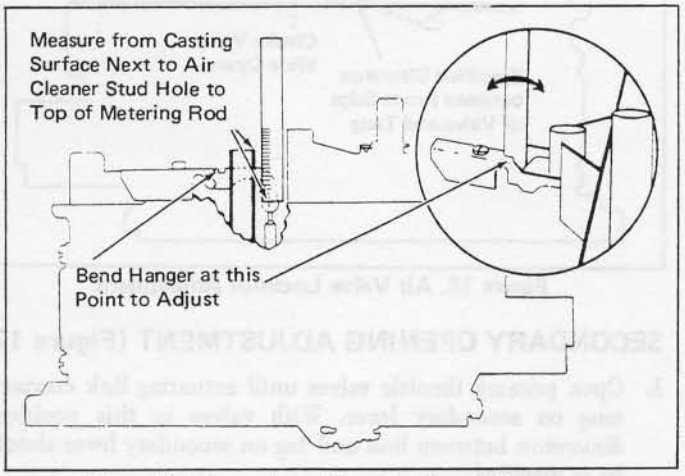


Figure 19. Secondary Metering Rod Adjustment

AIR VALVE SPRING ADJUSTMENT (Figure 20)

1. Loosen allen head lockscrew and turn adjusting screw counterclockwise to remove all spring tension.
2. With air valve closed, turn adjusting screw clockwise number of turns which are specified after torsion spring contacts pin on shaft. Hold adjusting screw in this position and tighten lockscrew.

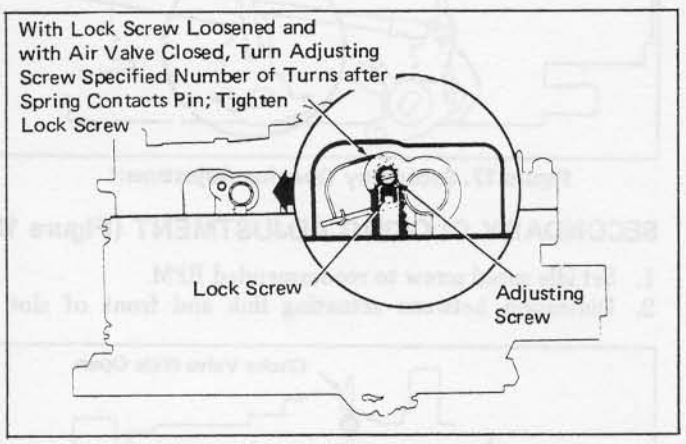


Figure 20. Air Valve Spring Adjustment

CHOKE COIL ROD ADJUSTMENT (Figure 21)

1. With choke valve completely closed and choke rod at bottom of choke lever slot, pull choke coil rod up to end of travel.
2. Rod should be positioned as shown. Bend choke coil rod to adjust.

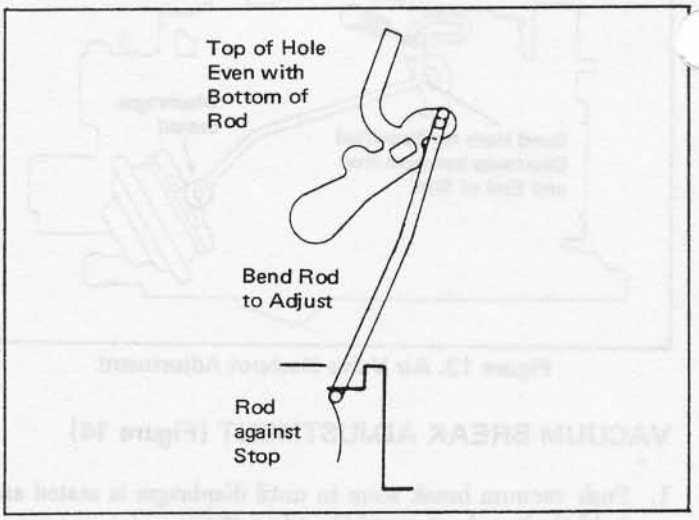


Figure 21. Choke Coil Rod Adjustment

IDLE SPEED and MIXTURE ADJUSTMENTS

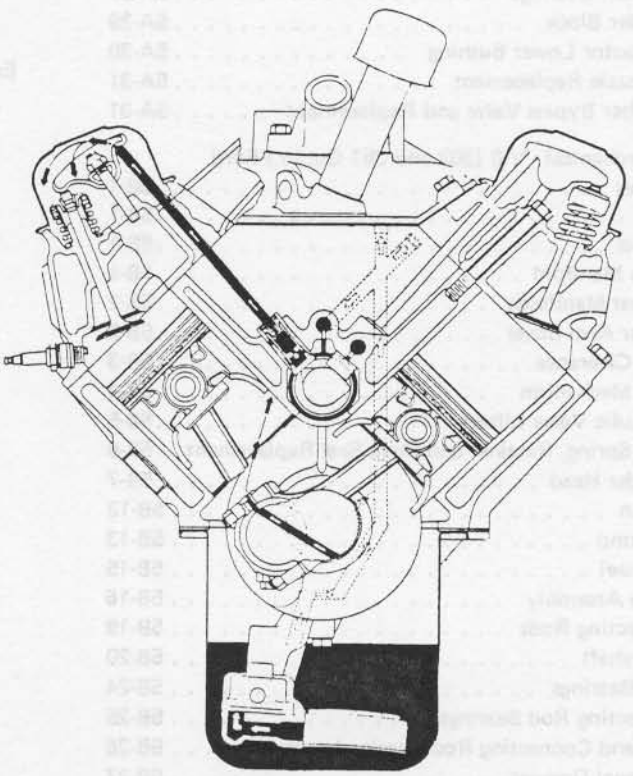
1. Be sure that flame arrestor is installed.
2. Start engine and allow to run until normal operating temperature is reached and choke is fully open.
3. Stop engine; disconnect throttle cable from engine.
4. Start engine. Adjust idle speed screw to obtain recommended idle RPM as indicated in "Specifications" Section 8.
5. Adjust idle mixture screw(s).

   IMPORTANT: Do not turn idle mixture screw(s) tightly against stop, or mixture needle and/or seat will be damaged.

6. Stop engine; turn idle mixture adjusting needles in until they very lightly just touch adjusting needle seat, then back needles off seats the specified number of turns for preliminary idle adjustment.
7. Start engine and run at idle RPM. Adjust idle mixture needle for highest, steadiest manifold vacuum reading. If a vacuum gauge is not available, obtain smoothest running, maximum idle speed by turning idle adjusting needle in until engine RPM begins to drop off, then backing needle off over "high spot" until engine RPM again drops off. Set idle adjusting needle halfway between the 2 points for satisfactory idle mixture setting. Repeat procedure with other needle. Should these adjustments show an increase in idle RPM, reset idle speed adjusting screw to obtain specified idle RPM and again adjust idle mixture adjusting needle.
8. Stop engine and install throttle cable, following. Check that throttle valves are fully open when remote control is in full forward position.
9. Shift unit into forward gear and re-adjust idle speed screw to obtain recommended idle RPM.

WARNING: Check all fuel connections for leaks.

ENGINE
MERCRUISER
Section 5



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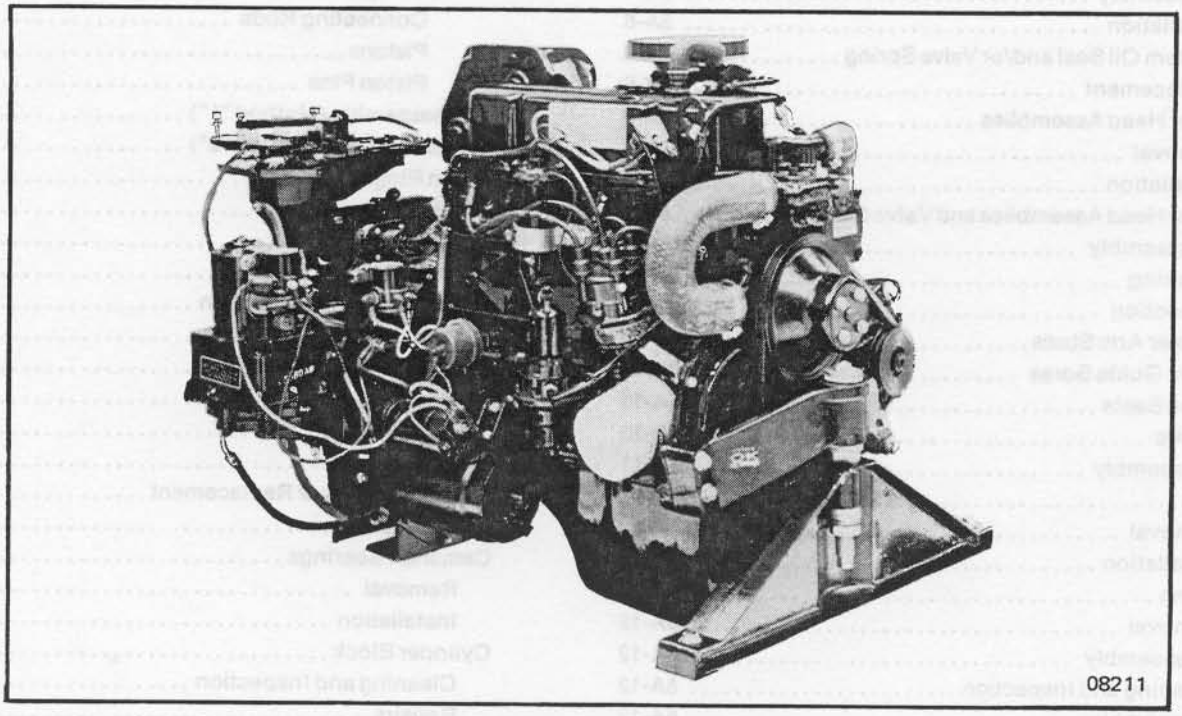
SECTION 5 - ENGINE

mercruiser

PART A - ENGINE MECHANICAL, IN-LINE



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ENGINE MECHANICAL - 4 and 6-CYLINDER MODELS

GENERAL

Some Repairs, Listed in This Section, Must Be Completed with Engine Removed from Boat. Engine Removal Depends Upon Type of Repair and Boat Design. Place Engine on Engine Stand for Major Repairs.

In-line engines with 153, 181, and 250 cu. in. displacements are covered in this section.

Full pressure lubrication thru a full flow oil filter is furnished by a gear-type oil pump. Distributor, driven by a helical gear on camshaft, drives oil pump. Main oil gallery feeds oil thru drilled passages to camshaft and crankshaft to lubricate bearings. Main oil gallery also feeds valve lifters which, thru push rods, feed individually-mounted rocker arms.

Cubic inch (and metric equivalent) displacement of each MerCruiser model is listed below.

Model	No. of Cylinders	Displacement
MerCruiser 120	4	153 Cu. In. (2507cc)
MerCruiser 140	4	181 Cu. In. (2966cc)
MerCruiser 165	6	250 Cu. In. (4097cc)

TOOLS

All "J-" (Special) Tools Listed in This Section May be Purchased from:

Kent-Moore, Inc.
28635 Mound Road
Warren, Mich. 48089

EXHAUST MANIFOLD

1 - Bolt (4)
2 - Washer (4)
3 - Screw
4 - Nut (2)
5 - Washer (2)
6 - Bolt (4)
7 - End Cap (Front)
8 - Gasket
9 - Exhaust Heat Tube
10 - Stud (2)
11 - Gasket
12 - Plug (4)
13 - Water Drain Plug
14 - Lockwasher (4)
15 - Nut (4)
16 - Exhaust Elbow
17 - Water Separation Tube
18 - Gasket
19 - Stud (4)
20 - Exhaust Manifold
21 - Gasket
22 - End Cap (rear)
23 - Bolt (4)
24 - Water Drain Plug
25 - Plug (2)
26 - Wiring Harness Clamp
27 - Lockwasher (1)
28 - Screw (1)
29 - Plug

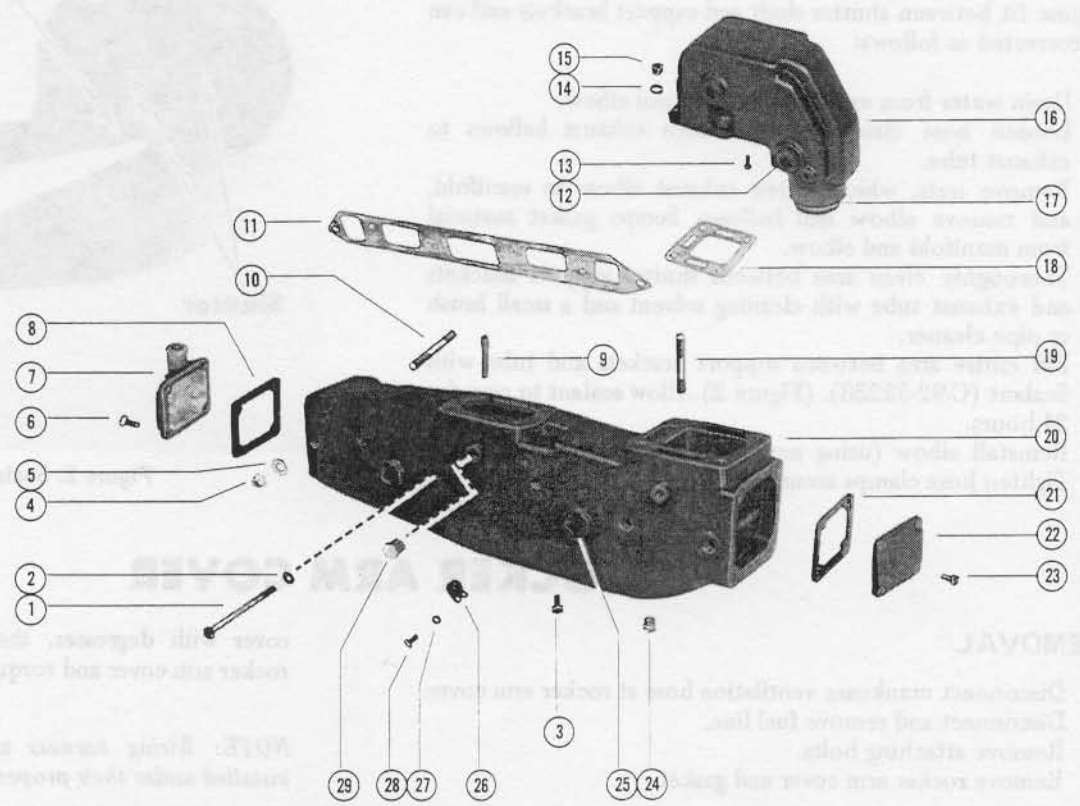


Figure 1. Typical Exhaust Manifold Assembly

REMOVAL

1. Drain water from block, exhaust manifold and exhaust elbow.
2. Disconnect throttle cable at carburetor.
3. Disconnect exhaust hose and cooling hose.
4. Disconnect fuel line at carburetor.
5. Disconnect crankcase ventilation hose at rocker arm cover.
6. Remove wiring harness clamps from manifold.
7. Disconnect alternator bracket from manifold.
8. Remove exhaust manifold fasteners; remove manifold assembly and discard gaskets.
9. Check for cracks in manifold castings.
10. If exhaust manifold requires replacement, transfer intake manifold (if applicable) and carburetor to new exhaust manifold.

CLEANING and INSPECTION

1. Clean gasket material from all surfaces and wash parts in solvent.
2. Inspect all parts carefully. Machined surfaces must be clean and free of all marks and deep scratches, or water and exhaust leaks may result.
3. Check water passages for sand, silt or foreign material. Passages must be clean for efficient cooling.
4. If more thorough inspection is desired, pipe plugs may be removed from exhaust manifold elbow and exhaust pipe elbow.

NOTE: If plugs are removed, coat threads with Sealant (C-92-52238) before reinstalling.

INSTALLATION

1. Clean gasket surfaces on cylinder head and manifold.
2. Position new gasket on head and carefully install manifold in position, making sure gasket is in place.
3. Install fasteners while holding manifold in place.
4. Tighten evenly and securely, starting in center and working out toward ends.

NOTE: Vibration will occur if fasteners (which secure manifold to cylinder head) loosen from compression of manifold to head gasket.

5. Connect crankcase ventilation hose at rocker arm cover.
6. Install alternator bracket to manifold.
7. Install wiring harness and clamps to manifold.
8. If exhaust manifold was replaced, transfer intake manifold (if applicable) and carburetor to new exhaust manifold.
9. Connect throttle cable at carburetor.
10. Connect fuel line and choke tube.
11. Reinstall exhaust hose and cooling hose.
12. Start engine, check for leaks and adjust carburetor idle speed and mixture.

EXHAUST WATER SHUTTER

The engine is equipped with exhaust shutter in exhaust tube, it may make a rattling noise at idle speed. This noise is caused by a loose fit between shutter shaft and support brackets and can be corrected as follows:

1. Drain water from exhaust manifold and elbow.
2. Loosen hose clamps which fasten exhaust bellows to exhaust tube.
3. Remove nuts, which fasten exhaust elbow to manifold, and remove elbow and bellows. Scrape gasket material from manifold and elbow.
4. Thoroughly clean area between shutter support brackets and exhaust tube with cleaning solvent and a small brush or pipe cleaner.
5. Fill entire area between support brackets and tube with Sealant (C-92-52238). (Figure 2) Allow sealant to cure for 24 hours.
6. Reinstall elbow (using new gasket) and connect bellows. Tighten hose clamps securely.

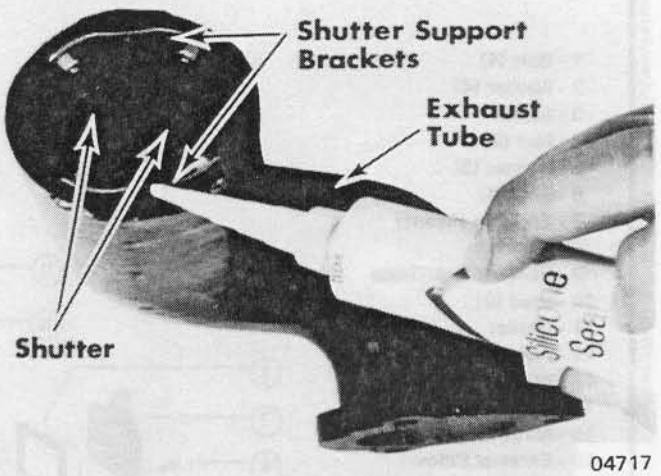


Figure 2. Sealant Application

ROCKER ARM COVER

REMOVAL

1. Disconnect crankcase ventilation hose at rocker arm cover.
2. Disconnect and remove fuel line.
3. Remove attaching bolts.
4. Remove rocker arm cover and gasket.

INSTALLATION

1. Clean gasket surfaces on cylinder head and rocker arm cover with degreaser, then, using a new gasket, install rocker arm cover and torque to specifications.

NOTE: Wiring harness and inlet hose clips must be installed under their proper screws.

2. Connect crankcase ventilation hoses.
3. Replace fuel line. Tighten connections securely and check for leaks.

VALVE MECHANISM

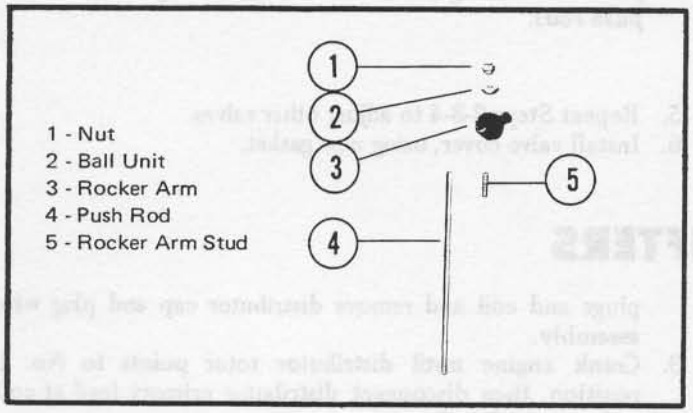


Figure 3. Valve Mechanism

REMOVAL

1. Remove rocker arm cover as outlined.
2. Remove rocker arm nuts, rocker arm balls, rocker arms and push rods.

   NOTE: Place rocker arms, rocker arm balls and push rods in a rack so that they may be reinstalled in same location.

INSTALLATION

NOTE: Whenever new rocker arms and/or rocker arm balls are being installed, coat bearing surfaces of rocker arms and rocker arm balls with engine oil.

1. Install push rods. Be sure that push rods seat in lifter socket.
2. Install rocker arms, rocker arm balls and rocker arm nuts. Tighten rocker arm nuts until all lash is eliminated.
3. Install rocker arm cover as outlined.
4. Adjust carburetor idle speed and mixture.

VALVE ADJUSTMENT

ENGINE STOPPED

1. Remove valve cover as outlined.
2. Adjust valves when lifter is on low lobe of camshaft, as follows:
   a. Mark distributor housing with chalk at No. 1 and No. 6 cylinder spark plug wire location for 6-cylinder engine and No. 1 and No. 4 for 4-cylinder engine. Disconnect plug wires at spark plugs and coil and remove distributor cap and plug wire assembly (if not previously done).

   NOTE: Valves are numbered as follows (starting from front of engine):

No. 1 - Exhaust	*No. 4 - Intake*	
No. 1 - Intake	*No. 4 - Exhaust*	
No. 2 - Intake	*No. 5 - Exhaust*	*6-Cyl. Only*
No. 2 - Exhaust	*No. 5 - Intake*	
No. 3 - Exhaust	*No. 6 - Intake*	
No. 3 - Intake	*No. 6 - Exhaust*	

   b. Use remote starter switch to crank engine until distributor rotor points to No. 1 cylinder position and breaker points are open. Following valves can be adjusted with engine in No. 1 firing position.
      No. 1 Cylinder--Exhaust and Intake
      No. 2 Cylinder--Intake
      No. 3 Cylinder--Exhaust
      No. 4 Cylinder--Intake
      No. 5 Cylinder--Exhaust (6-Cyl. Only)
   c. Back out adjusting nut until lash is felt at push rod, then turn in adjusting nut until all lash is removed. This can be determined by checking push rod end play (up and down) while turning adjusting nut. (Figure 4) When play is removed, turn adjusting nut in ¾ additional turn.
   d. Crank engine until distributor rotor points to No. 6 position for 6-cylinder engine and No. 4 for 4-cylinder engine (and breaker points are open). Following valves can be adjusted with engine in this position:
      No. 2 Cylinder--Exhaust
      No. 3 Cylinder--Intake
      No. 4 Cylinder--Exhaust
      No. 5 Cylinder--Intake (6-Cyl. Only)
      No. 6 Cylinder--Intake and Exhaust (6-Cyl. Only)
3. Install distributor cap, spark plug wires and coil lead.
4. Install rocker arm cover as outlined.
5. Adjust carburetor.

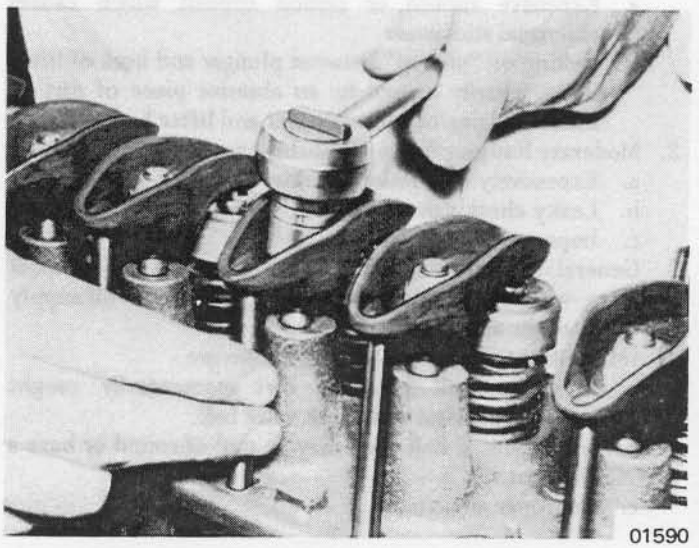


Figure 4. Valve Adjustment

ENGINE RUNNING

Following procedure should be completed only if readjustment is required.

1. Run engine until it reaches normal operating temperature, then remove valve cover.
2. With engine running at idle, back off valve rocker arm nut until valve rocker arm starts to clatter. (Figure 4)
3. Turn rocker arm nut down slowly until clatter just stops. This is zero lash position.

4. Turn nut down ¼ additional turn and pause 10 seconds until engine runs smoothly. Repeat additional ¼ turns, pausing 10 seconds each time, until nut has been turned down ¾ turn from zero lash position.

NOTE: This ¾ turn pre-load adjustment must be done slowly to allow lifter to adjust itself, thus preventing possible interference between inlet valve head and top of piston which might result in internal damage and/or bend push rods.

5. Repeat Steps 2-3-4 to adjust other valves.
6. Install valve cover, using new gasket.

VALVE LIFTERS

Refer to Figure 5 for parts identification.
Hydraulic valve lifters seldom require attention. Lifters are simple in design, readjustments are not necessary and lifter servicing requires only that care and cleanliness be exercised in handling of parts.

LOCATING NOISY LIFTERS

Use a piece of garden hose approximately 4 ft. (1.22m) in length to locate a noisy valve lifter. Place one end of hose near end of each intake and exhaust valve, with other end of hose to the ear. Sound, thus, is localized, making it easy to determine which lifter is at fault. Another method is to place a finger on face of valve spring retainer. If lifter is not functioning properly, a distinct shock will be felt when valve returns to its seat. General types of valve lifter noise are:

1. Hard Rapping Noise - Usually caused by plunger becoming tight in bore of lifter body to such an extent that return spring can no longer push plunger back up to working position. Probable causes are -
   a. Excessive varnish or carbon deposit which causes abnormal stickiness.
   b. Galling or "pickup" between plunger and bore of lifter body, usually caused by an abrasive piece of dirt or metal wedging between plunger and lifter body.
2. Moderate Rapping Noise - Probable causes are -
   a. Excessively high leakdown rate.
   b. Leaky check valve seat.
   c. Improper adjustment.
3. General Noise Throughout Valve Train - This, in most cases, will be a definite indication of insufficient oil supply or improper adjustment.
4. Intermittent Clicking - Probable causes are -
   a. A microscopic piece of dirt momentarily caught between ball seat and check valve ball.
   b. In rare cases, ball itself may be out- of-round or have a flat spot.
   c. Improper adjustment.

In most cases, where noise exists in one or more lifters, all lifter units should be removed, disassembled, cleaned in a solvent, reassembled and reinstalled in engine. If dirt, varnish, carbon, etc, are shown to exist in one unit, it likely exists in all units. Thus, it would be only a matter of time before all lifters cause trouble.

REMOVAL

1. Remove valve mechanism as outlined.
2. Mark distributor housing with chalk at each cylinder position (plug wire), then disconnect plug wires at spark plugs and coil and remove distributor cap and plug wire assembly.
3. Crank engine until distributor rotor points to No. 1 position, then disconnect distributor primary lead at coil and remove distributor.
4. Remove push rod covers (discard gaskets).
5. Remove valve lifters.

NOTE: Place valve lifters in a rack so they may be reinstalled in same location.

SERVICING

Two types of hydraulic lifters are used. Both types operate on same principle and are serviced basically in same manner. Complete lifter assemblies are interchangeable, but parts from one lifter are not interchangeable with another. Both lifters are easily identified by outside configuration of lifter body. Identify them as lifter "A" and lifter "B". (Figure 5)

DISASSEMBLY

1. Hold plunger down with push rod and remove push rod seat retainer with blade of small screwdriver.
2. Remove push rod seat and metering valve (lifter "A") or push rod seat and inertia valve assembly (lifter "B"). (Figure 5)
3. Remove plunger, ball check valve assembly and plunger spring.
4. Remove ball check valve and spring by prying ball retainer loose from plunger with blade of small screwdriver. (Figure 6)

CLEANING and INSPECTION

Thoroughly clean all parts in cleaning solvent and inspect parts carefully. If any parts are damaged or worn, entire lifter assembly should be replaced. If outside of lifter body is scuffed or worn, inspect cylinder block lifter bore. If bottom of lifter is scuffed or worn, inspect camshaft lobe. If push rod seat is scuffed or worn, inspect push rod.

NOTE: Do not remove inertia valve and retainer (lifter "B") (Figure 5) from push rod seat. To check valve, shake push rod seat and inertia valve assembly. Valve should move.

REASSEMBLY

1. Place check ball on small hole in bottom of plunger.

2. Insert check ball spring on seat in ball retainer and place retainer over ball so that spring rests on ball. Carefully press retainer into position in plunger with blade of a small screwdriver. (Figure 7)

CAUTION: Do not attempt to force or pump the plunger.

3. Place plunger spring over ball retainer and slide lifter body over spring and plunger, being careful that oil feed holes in lifter body and plunger line up.

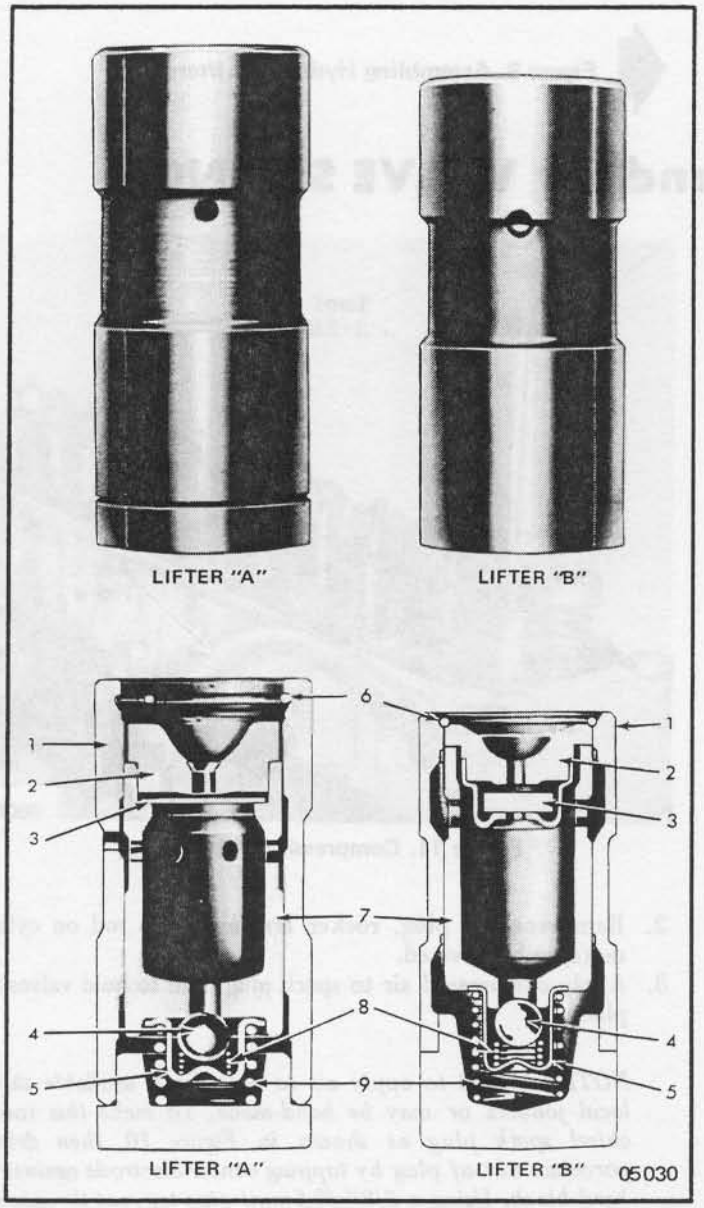


Figure 5. Hydraulic Valve Lifters

1 - Lifter Body
2 - Push Rod Seat
3 - Metering Valve (Lifter "A")
Inertia Valve (Lifter "B")
4 - Check Ball
5 - Check Ball Retainer
6 - Push Rod Seat Retainer
7 - Plunger
8 - Check Ball Spring
9 - Plunger Spring

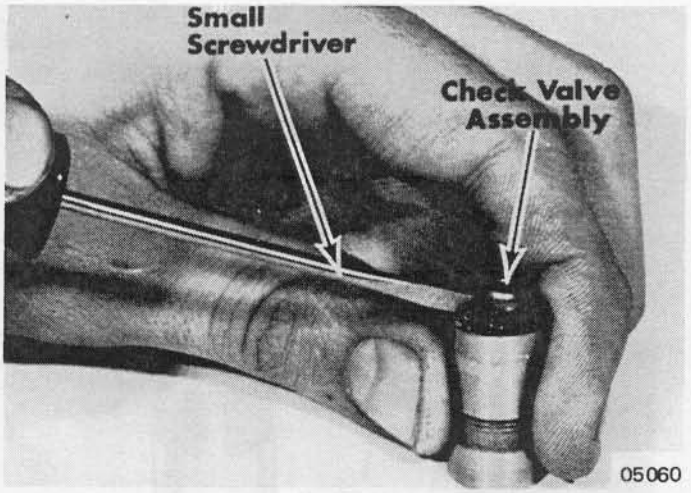


Figure 6. Removing Ball Check Valve

4. Fill assembly with oil, then insert end of a 1/8" (3.2mm) drift pin into plunger and press down strongly. At this point, oil holes in lifter body and plunger assembly will be aligned. (Figure 8)
5. Insert a 1/16" (1.6mm) drift pin thru both oil holes to hold plunger down against lifter spring tension. (Figure 8)

NOTE: On lifter "B" (Figure 5), drift pin must not extend inside plunger.

6. Remove 1/8" drift pin and refill assembly with oil.
7. Install metering valve and push rod seat (lifter "A") or push rod seat and inertia valve assembly (lifter "B"). (Figure 5)
8. Install push rod seat retainer, press down on push rod seat and remove 1/16" drift pin from oil holes. Lifter now is completely assembled, filled with oil and ready for installation.

NOTE: Before installing a new lifter, coat bottom of lifter with engine oil.

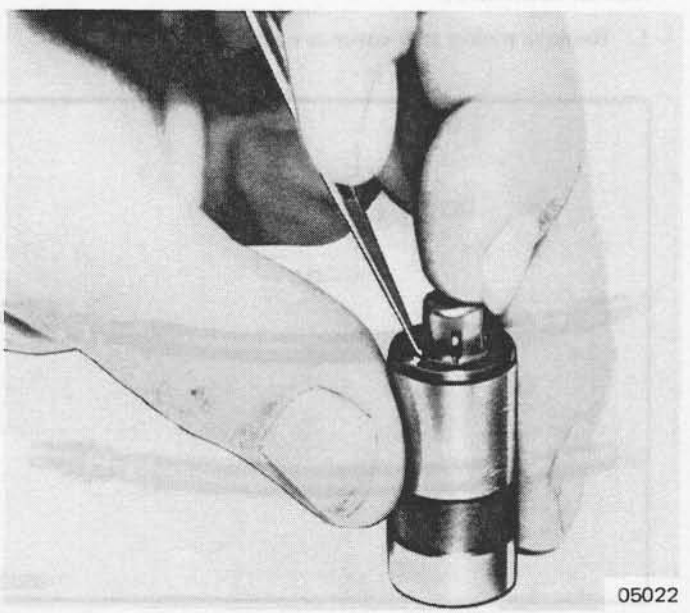
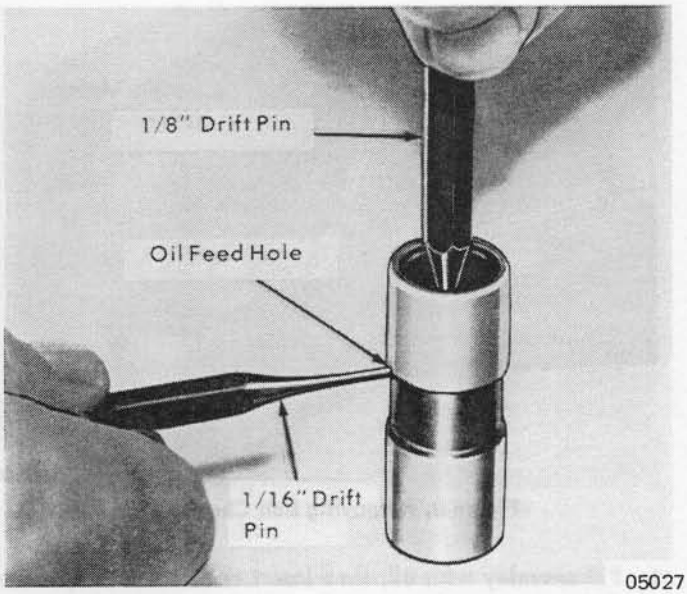


Figure 7. Installing Ball Check Valve



INSTALLATION

1. Install valve lifters.

   NOTE: Whenever valve lifters are being installed, co bottom of valve lifters with engine oil.

2. Install push rod covers, using new gaskets, and torque to specifications.
3. Install distributor, positioning rotor to No. 1 cylinder position, then connect primary lead at coil.
4. Install distributor cap and high tension wires.
5. Install and adjust valve mechanism as outlined.
6. Adjust ignition timing with timing light and adjust carburetor idle speed and mixture.

Figure 8. Assembling Hydraulic Lifters

VALVE STEM OIL SEAL and/or VALVE SPRING

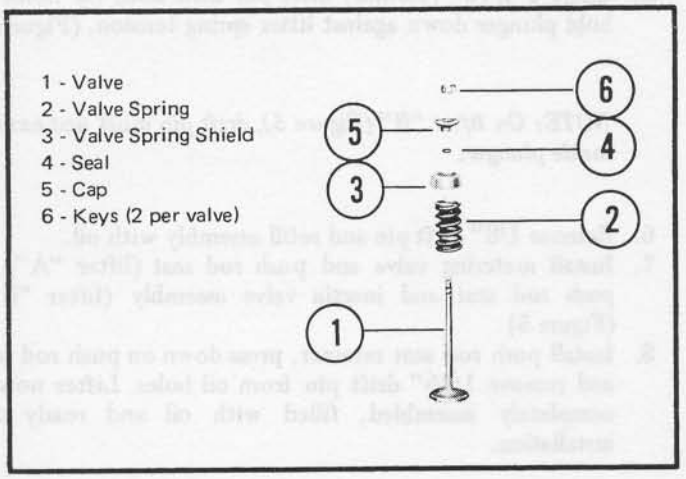


Figure 9. Valve Spring and Related Parts

REPLACEMENT

1. Remove rocker arm cover as outlined.

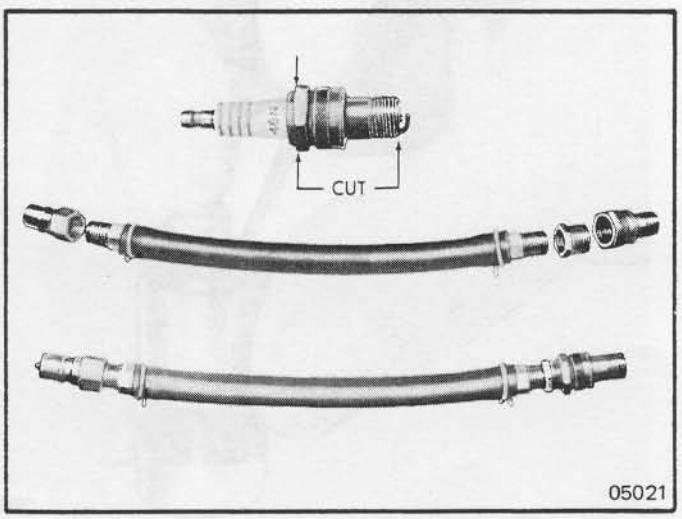


Figure 10. Air Adaptor Tool

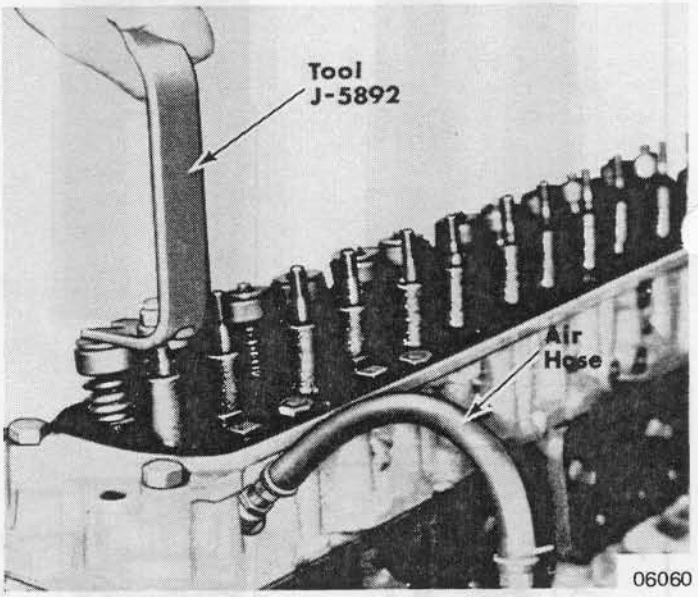


Figure 11. Compressing Valve Spring

2. Remove spark plug, rocker arm and push rod on cylinder(s) to be serviced.
3. Apply compressed air to spark plug hole to hold valves in place.

   NOTE: A tool to apply air to cylinder is available thru local jobbers or may be hand-made. To make this tool, chisel spark plug as shown in Figure 10, then drive porcelain out of plug by tapping center electrode against a hard block. Using a 3/8" (9.5mm) pipe tap, cut threads in remaining portion of spark plug and assemble as shown in Figure 10. (Later engines use tapered plug.)

4. Compress valve spring with Tool J-5892 and remove valve keys, valve spring cap, spring shield and valve spring. (Figure 11)
5. Remove valve stem oil seal.

6. To replace, set valve spring, valve shield and valve cap in place. (Close, coiled end of spring is installed against cylinder head.) Compress spring with Tool J-5892 and install oil seal in lower groove of stem, making sure that seal is flat and not twisted.

   NOTE: A light coat of oil on seal will help prevent twisiting when compressor tool is released.

7. Install valve keys and release compressor tool. Be sure that keys seat properly in upper groove of valve stem.

   NOTE: Grease may be used to hold keys in place while releasing compressor tool.

8. Install spark plug, using a new gasket, and torque to specifications.
9. Install and adjust valve mechanism as outlined.

CYLINDER HEAD ASSEMBLIES

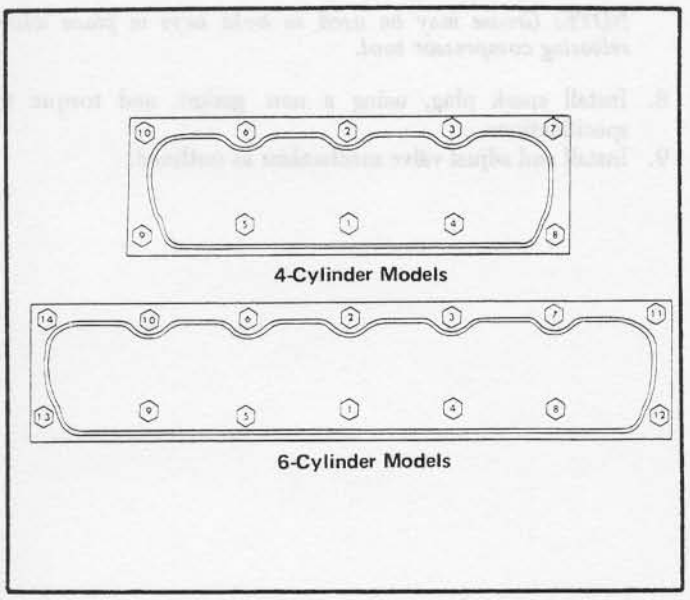


Figure 1. Cylinder Head Torque Sequence

REMOVAL

1. Drain water from cylinder block and manifold.
2. Disconnect fuel line support clamps and remove fuel line.
3. Remove exhaust manifold as outlined.
4. Disconnect cooling hoses water distribution housing.
5. Disconnect wire from temperature sending unit (located in water distribution housing) and remove water distribution housing from cylinder head.
6. Disconnect wires from coil and remove coil.
7. Remove circuit breaker bracket and lifting eye.
8. Disconnect spark plug leads from spark plugs and remove all spark plugs from cylinder head.
9. Remove rocker arm cover and valve mechanism as outlined.
10. Remove cylinder head bolts, cylinder head and gasket. Handle cylinder head carefully to prevent damage.

INSTALLATION

CAUTION: Gasket surfaces on both head and block must be clean of any foreign matter and free of nicks and/or deep scratches. Cylinder bolt threads in block, and threads on cylinder head bolt must be cleaned. Dirt will affect bolt torque. DO NOT use gasket sealer on composition steel asbestos gaskets.

1. Place new gasket in position over dowel pins.

CAUTION: DO NOT use steel automotive type cylinder head gaskets. Use only MerCap replacement parts.

2. Carefully guide cylinder head into place over dowel pins and gasket.
3. Coat threads of cylinder head bolts with Perfect Seal (C-92-34227) and install finger-tight.
4. Tighten cylinder head bolts a little at a time in sequence shown on torque sequence chart (Figure 1) until specified torque is reached.

NOTE: Be sure to torque cylinder head on all 6-cylinder engines while performing 20-hour checkup. Failure to retorque could result in poor engine performance, blown cylinder head gaskets, burned valves, warped cylinder head or all four.

5. Install valve mechanism and rocker arm cover as outlined.
6. Install spark plugs and spark plug leads to proper plugs.
7. Install lifting eye and circuit breaker bracket.
8. Install coil and coil leads.
9. Install water distribution housing to cylinder head and connect temperature sending unit lead.
10. Connect cooling hoses to water distribution housing.
11. Install exhaust manifold as outlined.
12. Install fuel line and fuel line support clamps.

CYLINDER HEAD ASSEMBLIES and VALVE CONDITIONING

DISASSEMBLY

1. Remove cylinder head as outlined.
2. Compress the valve springs with Tool J-8062 (Figure 2) and remove valve keys. Release compressor tool and remove spring caps, spring shields and valve springs. Remove oil seals from valves.
3. Remove valves from cylinder head and place them in a rack in their proper sequence for later assembly in their original positions.

CLEANING

1. Clean all carbon from combustion chambers and valve ports with Tool J-8089. (Figure 3)
2. Thoroughly clean valve guides with Tool J-8101. (Figure 4)
3. Clean all sludge from push rods, rocker arms and push rod guides.
4. Clean valve stems and valve heads on a buffing wheel.
5. Clean cylinder head gasket mating surface.

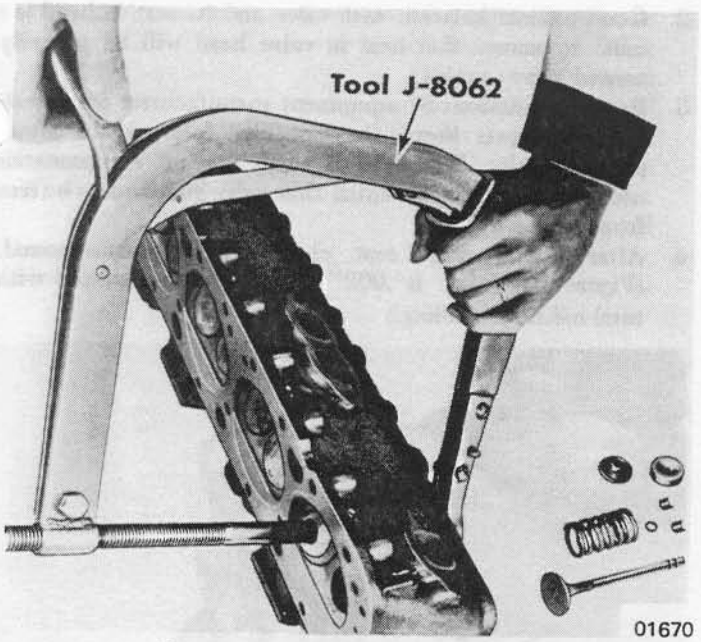


Figure 2. Compressing Valve Spring

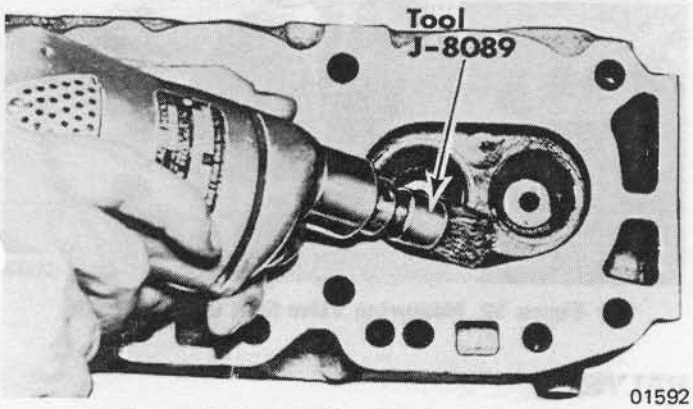


Figure 3. Cleaning Combustion Chambers

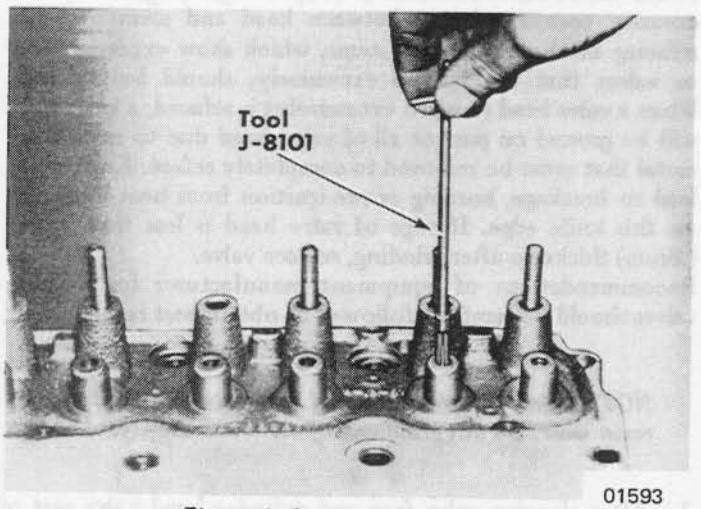


Figure 4. Cleaning Valve Guides

INSPECTION

1. Inspect cylinder head gasket surface for flatness. Max. is .003" (.076mm) warpage in any 6" (15cm) area or .007" (.178mm) overall. If not within specifications, resurface or replace cylinder head.
2. Inspect cylinder head for cracks in exhaust ports, combustion chambers or external cracks to water chamber.
3. Inspect valves for burned heads, cracked faces or damaged stems.

   NOTE: Excessive valve stem to bore clearance will cause excessive oil consumption and may cause valve breakage. Insufficient clearance will result in noisy and sticky valves and disturb smooth engine operation.

4. Measure valve stem clearance as follows: Clamp a dial indicator on one side of cylinder head rocker arm cover gasket rail, locating indicator so that movement of valve stem from side-to-side (crosswise to head) will cause a direct movement of indicator stem. Indicator stem must contact side of valve stem just above valve guide. With valve head dropped about 1/16" (1.6mm) off valve seat, move stem of valve from side-to-side, using light pressure to obtain a clearance reading. If clearance exceeds specifications, it will be necessary to ream valve guides for oversize valves as outlined.
5. Check valve spring tension with Tool J-8056 spring tester. (Figure 5)

   NOTE: Compress springs to specified height and check against specification chart. Replace if not within 10 lbs. of specified load (without dampers).

6. Inspect rocker arm studs for wear or damage.

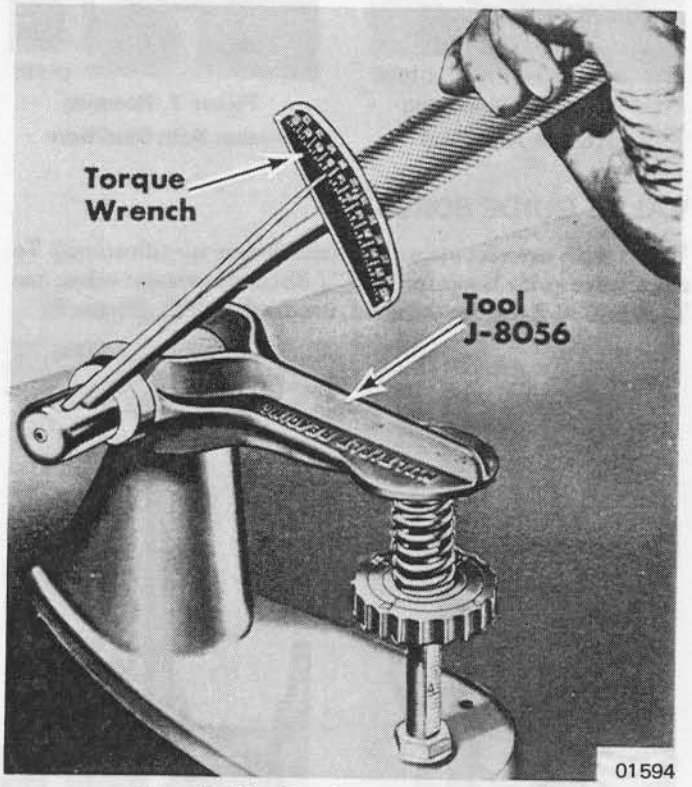


Figure 5. Checking Valve Spring Tension

ROCKER ARM STUDS

Rocker arm studs with damaged threads or with loose fit in cylinder heads should be replaced with new studs available in .003" and .013" (.076mm and .330mm) oversize. Studs may be installed after reaming holes as follows:

1. Drain water from cylinder block.
2. Remove old stud by placing Tool J-5802-1 over stud, installing nut and flat washer and removing stud by turning nut. (Figure 6)
3. Ream hole for oversize stud with Tool J-5715 for .003" (.076mm) oversize or Tool J-6036 for .013" (.33mm) oversize. (Figure 7)

CAUTION: Do not attempt to install an oversize stud without reaming stud hole.

4. Coat press-fit area of stud with Perfect Seal (C-92-34227). Install new stud, using Tool J-6880 as a guide. Gauge should bottom on head. (Figure 8)

Figure 6. Removing Rocker Arm Stud

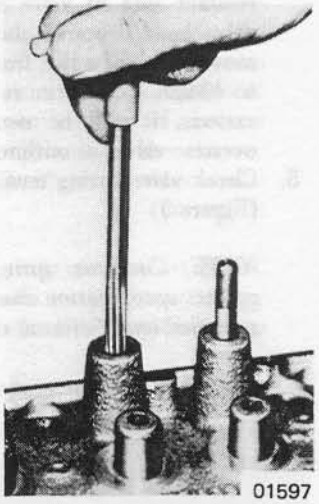


Figure 7. Reaming Rocker Arm Stud Bore

VALVE GUIDE BORES

Valves with oversize stems are available (see specifications). To ream valve guide bores for .015" (.381mm) oversize valves, use Tool J-5830-2 and for standard, use Tool J-4822. (Figure 9)

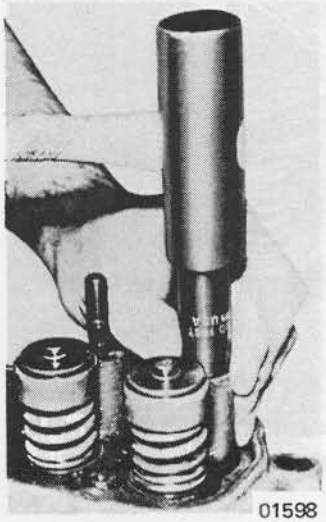


Figure 8. Installing Rocker Arm Stud

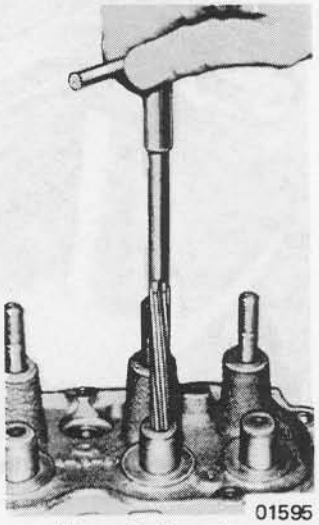


Figure 9. Reaming Valve Guide

VALVE SEATS

1. Valves must seat perfect for the engine to deliver the power and performance built into it.
2. Good contact between each valve and its seat in head is a must to ensure that heat in valve head will be properly carried away (cooled).
3. Recommendations of equipment manufacturer for reseating valve seats should be carefully followed to attain proper results. Regardless of what type of equipment is used, however, it is essential that valve guide bores be free from carbon or dirt.
4. After grinding valve seat, check seat for out-of-round. (Figure 10) (Max. is .002" [.05mm] out-of-round with total indicator reading.)

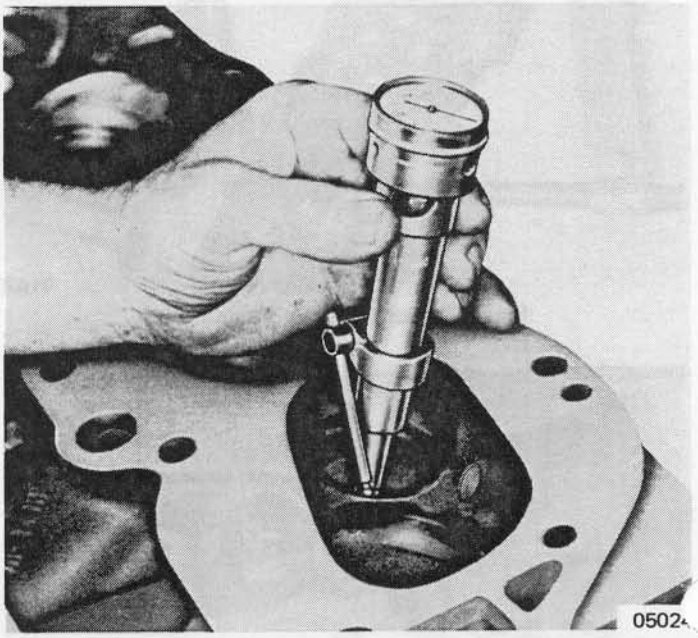


Figure 10. Measuring Valve Seat Concentricity

VALVES

Pitted valves can be refaced to proper angle (Figure 11) thus ensuring correct relation between head and stem on valve refacing mechanism. Valve stems, which show excessive wear or valves that are warped excessively, should be replaced. When a valve head (warped excessively) is refaced, a knife edge will be ground on part or all of valve head due to amount of metal that must be removed to completely reface. Knife edges lead to breakage, burning or pre-ignition from heat localizing on this knife edge. If edge of valve head is less than 1/32" (.8mm) thickness after grinding, replace valve.
Recommendations of equipment manufacturer for refacing valves should be carefully followed to obtain best results.

NOTE: Only extreme end of valve stem is hardened to resist wear. Do not grind end of stem excessively.

1. After cleaning valve face and cylinder head valve seat of grinding particles, make pencil marks about ¼" (6.4mm) apart across valve face, place valve in cylinder head and give valve ½-turn in each direction while exerting firm pressure on head of valve.
2. Remove valve and check face carefully. If all pencil marks have not been removed at point of contact with valve seat, it will be necessary to repeat refacing operation and again recheck for proper seating.
3. Grind and check remaining valves in same manner.

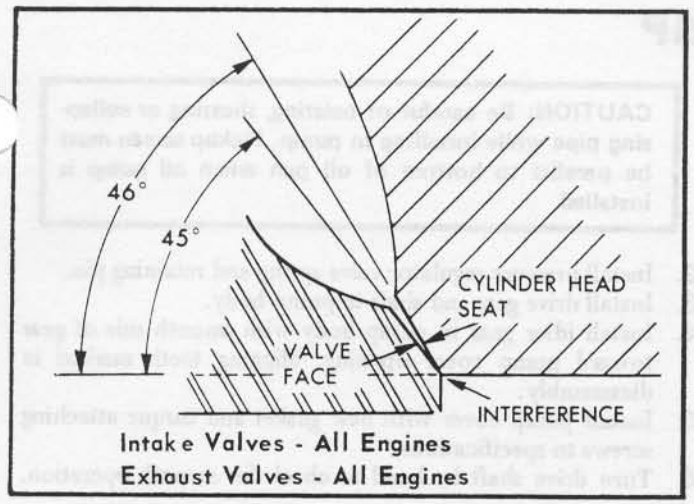


Figure 11. Relation of Valve and Seat Angles

REASSEMBLY

1. Insert valve in proper port.
2. Assemble valve spring and related parts as follows:
   a. Set valve spring, valve shield and valve cap in place. (Figure 12) Close, coiled end of spring is installed against cylinder head.
   b. Compress spring with Tool J-8062.
   c. Install oil seal in lower groove of stem, making sure that seal is flat and not twisted.

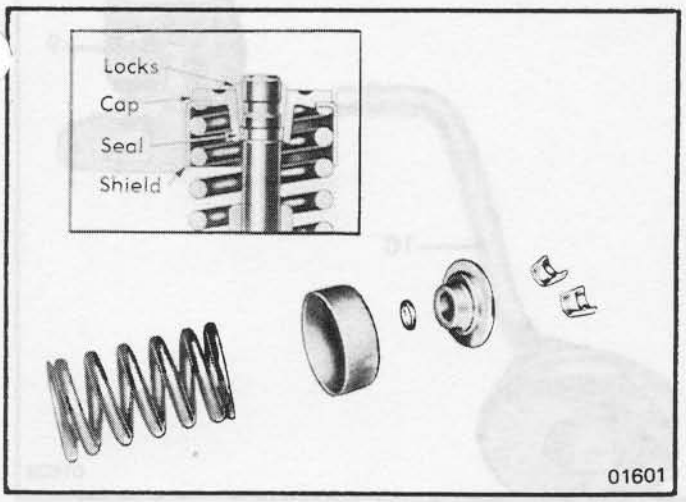


Figure 12. Valve Spring Installation

NOTE: A light coat of oil on seal will help prevent twisting when compressor tool is released.

   d. Install valve locks and release compressor tool, making sure that locks seat properly in upper groove of valve stem.

   NOTE: Grease may be used to hold locks in place while releasing compressor tool.

3. Install remaining valves.

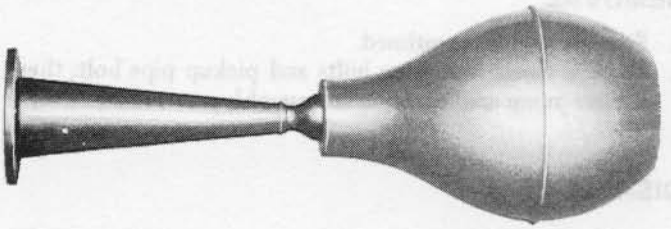


Figure 13. Vacuum Cup

4. Check each valve stem oil seal by placing a vacuum cup or similar device over end of valve stem and against cap. Operate vacuum cup and make sure that no air leaks past seal. A vacuum cup can be made from a small syringe and a high voltage shield. (Figure 13)

5. Check installed height of valve springs with scale. (Figure 14) Measure from top of spring seat to top of valve spring shield. (Figure 14) If this exceeds specified height, install a valve spring seat shim approximately 1/16" (1.6mm) thick. At no time should spring be shimmed to give an installed height under minimum specified.

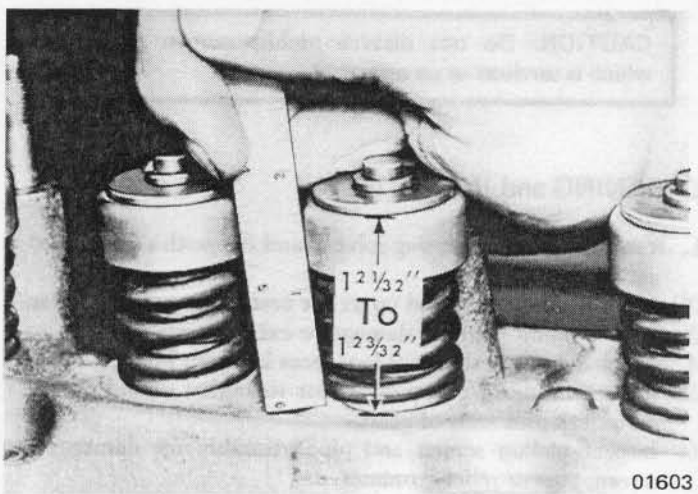


Figure 14. Checking Valve Spring Installed Height

OIL PAN

REMOVAL

1. Disconnect battery (if connected).
2. Drain engine oil.
3. Remove starter motor.
4. Remove oil pan screws, oil pan, side and end gaskets.

INSTALLATION

1. Thoroughly clean all gasket sealing surfaces.
2. Install rear gasket (rubber) in rear main bearing cap.
3. Install front gasket (rubber) on timing gear cover.
4. Install side gaskets on cylinder block, using grease as a retainer. Locate side gasket tabs into notches of front seal.
5. Install oil pan.
6. Install starter motor.
7. Fill crankcase with oil.
8. Connect battery.

OIL PUMP

Oil pump consists of 2 gears and a pressure regulator valve enclosed in a 2-piece housing. Oil pump is driven by distributor shaft which is driven by a helical gear on camshaft. A baffle is incorporated on pickup screen to eliminate pressure loss. Use Figure 15 for reference.

REMOVAL

1. Remove oil pan as outlined.
2. Remove flange mounting bolts and pickup pipe bolt, then remove pump and screen as an assembly.

DISASSEMBLY

NOTE: DO NOT remove pickup screen and pipe assembly unless replacement is necessary. Loss of press fit condition could result in air leak and loss of oil pressure.

1. Remove pump cover attaching screws, pump cover and pump cover gasket.

NOTE: Mark gear teeth so they may be reassembled with same teeth indexing.

2. Remove idler gear and drive gear and shaft from pump body.
3. Remove pressure regulator valve retaining pin, pressure regulator, spring and valve.
4. If pickup screen and pipe assembly need replacing, mount pump in a soft-jawed vise and extract pipe from pump.

CAUTION: Do not disturb pickup screen on pipe which is serviced as an assembly.

CLEANING and INSPECTION

1. Wash all parts in cleaning solvent and dry with compressed air.
2. Inspect pump body and cover for cracks or excessive wear.
3. Inspect pump gears for damage or excessive wear.
4. Check drive gear shaft for looseness in pump body.
5. Inspect inside of pump cover for wear that would permit oil to leak past ends of gears.
6. Inspect pickup screen and pipe assembly for damage to screen, pipe or relief grommet.
7. Check pressure regulator valve for fit.

NOTE: Pump gears and body are not serviced separately. If pump gears or body are damaged or worn, replace entire oil pump assembly.

REASSEMBLY

1. If pickup screen and pipe assembly was removed, replace with a new part. Loss of press fit condition could result in air leak and loss of oil pressure. Mount pump in soft-jawed vise and apply Perfect Seal No. 4 (C-92-34227) to end of pipe with Tool J-8369. Tap pipe in place with plastic hammer.

CAUTION: Be careful of twisting, shearing or collapsing pipe while installing in pump. Pickup screen must be parallel to bottom of oil pan when oil pump is installed.

2. Install pressure regulator valve spring and retaining pin.
3. Install drive gear and shaft in pump body.
4. Install idler gear in pump body with smooth side of gear toward pump cover opening, aligning teeth marked in disassembly.
5. Install pump cover with new gasket and torque attaching screws to specifications.
6. Turn drive shaft by hand to check for smooth operation.

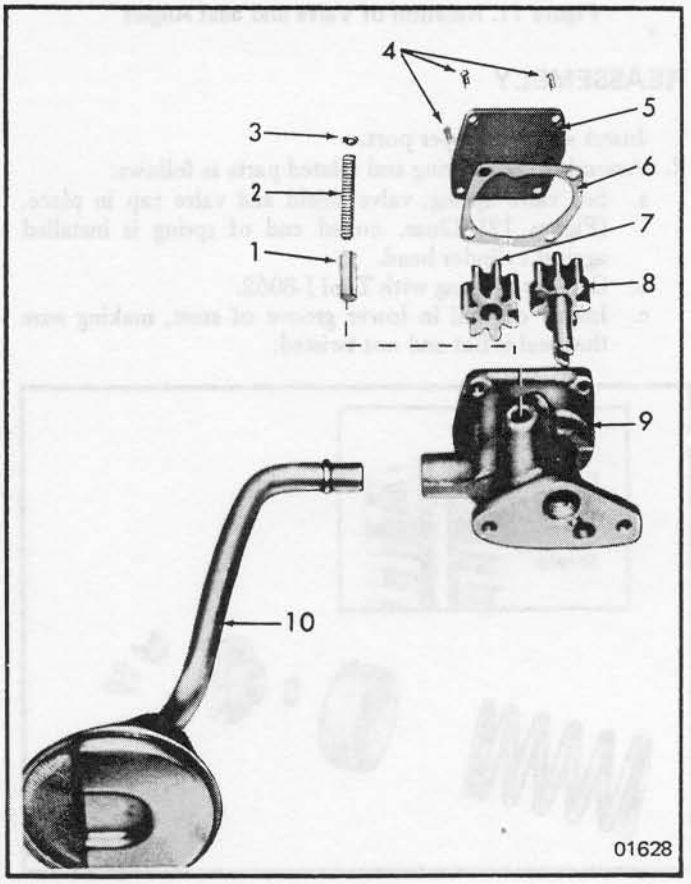


Figure 15. Oil Pump

1 - Pressure Regulator Valve
2 - Pressure Regulator Spring
3 - Retaining Pin
4 - Screws
5 - Pump Cover
6 - Cover Gasket
7 - Idler Gear
8 - Drive Gear and Shaft
9 - Pump Body
10 - Pickup Screen and Pipe

INSTALLATION

1. Align oil pump drive shafts to match with distributor tang, then install oil pump to block, positioning flange over distributor lower bushing. Use no gasket.

NOTE: Oil pump should slide easily into place. If not, remove and reposition slot to align with distributor tang.

2. Install oil pump bolts and tighten securely.
3. Install oil pan as outlined.

CRANKSHAFT PULLEY

REMOVAL

1. Support front of engine (if in boat) with overhead hoist.
2. Remove front mounting bracket and drive belt. Remove crankshaft pulley from pulley hub.
3. Install puller Tool J-6978 to pulley hub with two 3/8 x 2" and one 5/16 x 2" bolts and remove hub. (Figure 1) Remove puller tool.

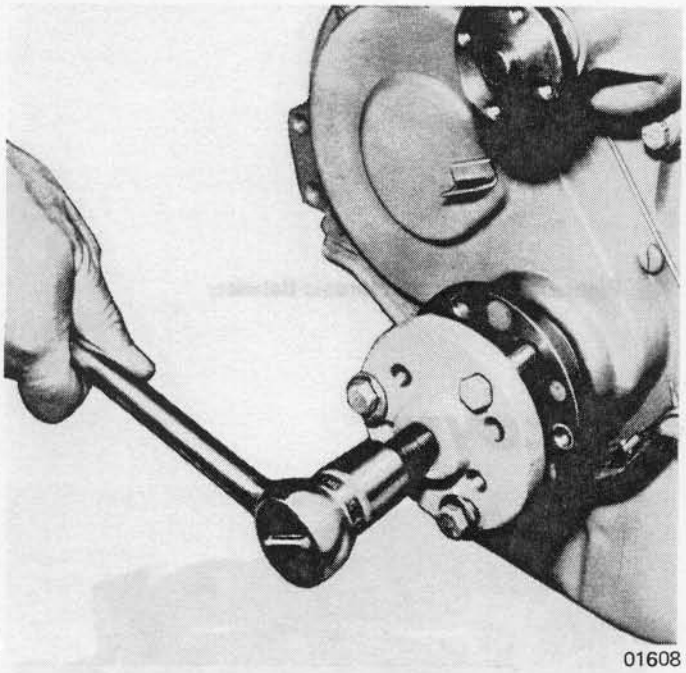


Figure 1. Removing Crankshaft Pulley Hub

INSTALLATION

1. Coat oil seal lip with engine oil, position hub over crankshaft and key and start hub into position with a mallet. Using Tool J-5590, strike hub until it bottoms against crankshaft gear.

   NOTE: Crankshaft extends slightly thru hub, and a tool is necessary to drive hub completely into bottomed position.

2. Install pulley onto hub.

   NOTE: There are two 3/8" (9.5mm) holes and one 5/16" (7.9mm) hole that must be matched on hub in order to properly position timing mark. (Figure 2)

3. Install drive belt and adjust tension.
4. Install front mounting bracket.

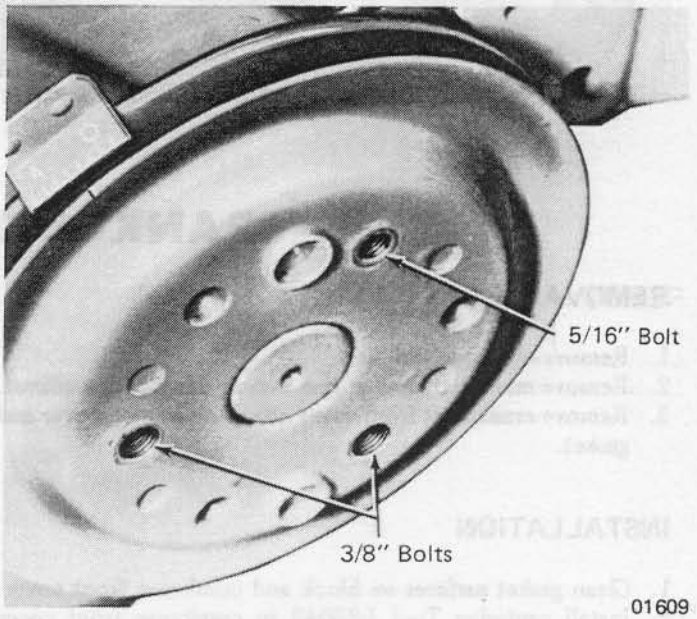


Figure 2. Install Pulley To Hub

TORSIONAL DAMPER

REMOVAL

1. Support front of engine (if in boat) with overhead hoist.
2. Remove front mounting bracket and drive belt. (Remove retaining bolt, if so equipped.)
3. Install Tool J-6978 to balancer and turn puller screw to remove damper. (Figure 3) Remove tool from damper.

CAUTION: Inertia weight section of torsional damper is assembled to hub with rubber type material. Installation procedures (with proper tool) must be followed or movement of inertia weight section on hub will upset tuning of torsional damper.

INSTALLATION

1. Coat front cover oil seal lip with engine oil.
2. Attach damper installer Tool J-8792 to damper as shown in Figure 4.

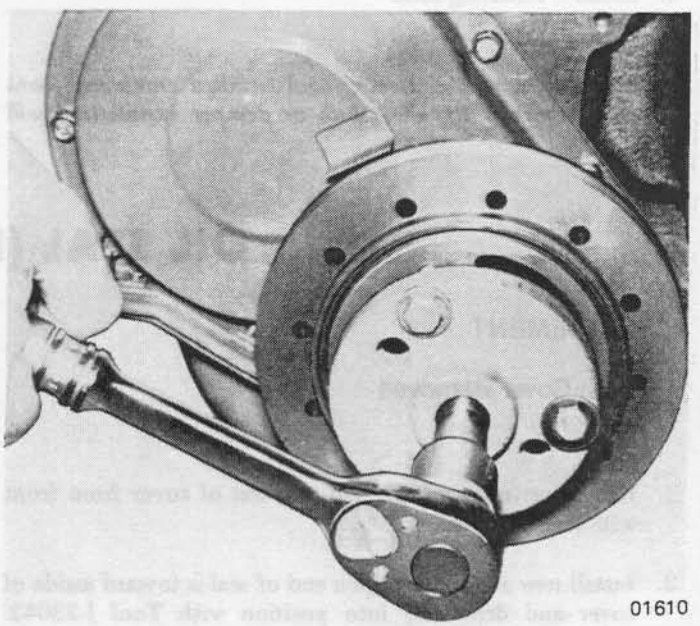
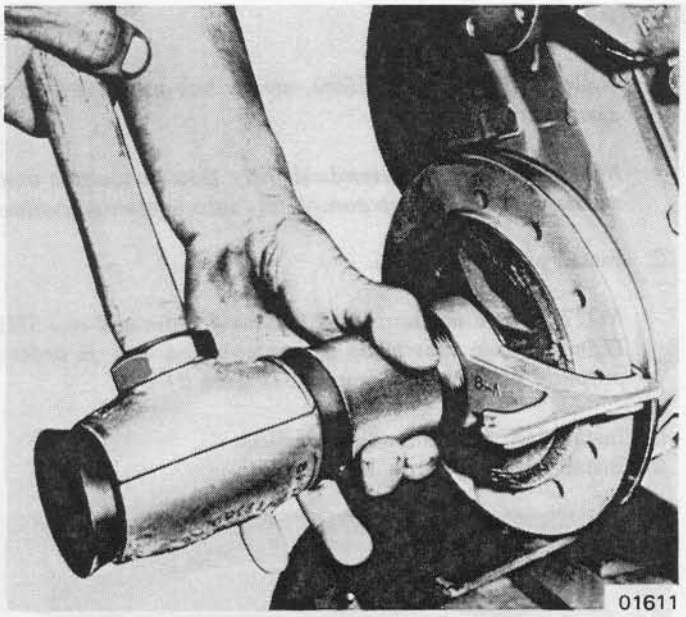


Figure 3. Removing Harmonic Balancer



3. Position damper on crankshaft and drive into position until it bottoms against crankshaft gear.
4. Remove installation tool.
5. Install drive belt and adjust tension.
6. Install front mounting bracket.

Figure 4. Installing Harmonic Balancer

CRANKCASE FRONT COVER

REMOVAL

1. Remove oil pan as outlined.
2. Remove crankshaft pulley and hub or damper as outlined.
3. Remove crankshaft front cover attaching screws, cover and gasket.

INSTALLATION

1. Clean gasket surfaces on block and crankcase front cover.
2. Install centering Tool J-23042 in crankcase front cover seal. (Figure 5)
3. Coat gasket with gasket sealer and place in position on cover, then install crankcase front cover to block and torque to specifications.
4. Remove centering tool.

NOTE: Use only centering tool to align crankcase front cover so that crankshaft hub or damper installation will not damage seal and to position seal to seal evenly around damper or hub surface.

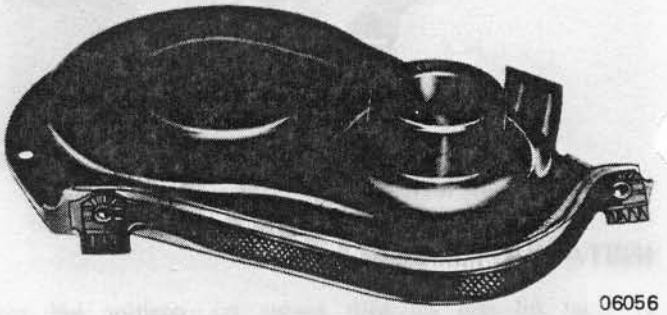


Figure 5. Centering Tool (J-23042) In Cover

5. Install crankshaft hub and/or damper as outlined.
6. Install oil pan as outlined.

OIL SEAL (FRONT COVER)

REPLACEMENT

With Cover Removed

1. With cover removed, pry old seal out of cover from front with large screwdriver.
2. Install new seal so that open end of seal is toward inside of cover and drive seal into position with Tool J-23042. (Figure 6)

CAUTION: Support cover at sealing area. Tool J-971 may be used as support.

Without Cover Removed

1. With crankshaft pulley and hub or damper removed, pry old seal out of cover from front with large screwdriver, being careful not do damage seal surface on crankshaft.
2. Install new seal so that open end of seal is toward inside of cover and drive seal into position with Tool J-23042. (Figure 7)

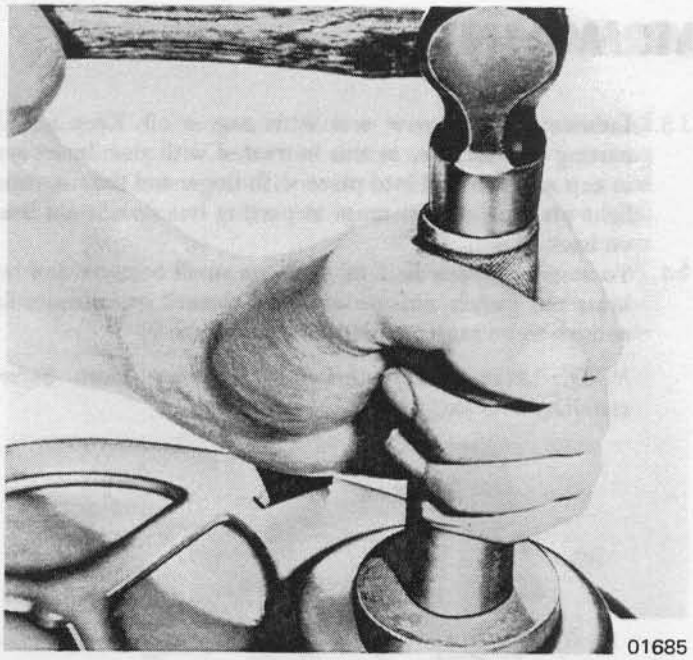


Figure 6. Installing Oil Seal (Cover Removed)

Figure 7. Installing Oil Seal (Cover Installed)

FLYWHEEL and COUPLER

REMOVAL

1. Remove engine from boat.
2. Remove bell housing.
3. Remove coupler by removing retaining nuts and washers.
4. Remove flywheel.

INSPECTION

Engine Coupling

1. Failure of engine coupling assembly spline and/or universal splined shaft caused by insufficient lubrication at time of installation. On initial installation and whenever a stern drive unit is removed, lubricate engine coupling splines with Multipurpose Lubricant (C-92-63250). The spline mating surfaces will wear very rapidly if installed dry.

   NOTE: In applications where trolling constitutes most of the operation time, Universal Joint Lubricant (C-92-74058A1) will provide more satisfactory service.

2. Hub bond, which shears or pulls loose from hub center, indicates engine drive misalignment. Align engine with correct alignment tool.

Flywheel

Check flywheel ring gear for worn or missing teeth.

INSTALLATION

1. Install flywheel. Line up dowel hole in flywheel with dowel hole in crankshaft flange and set flywheel in place on studs. (Figure 8)
2. Place drive coupling on studs and install washers and lock nuts. Torque nuts to specifications with Torque Wrench and Adaptor (C-91-54638).
3. Install bell housing.
4. Lubricate coupler splines and install engine in boat.

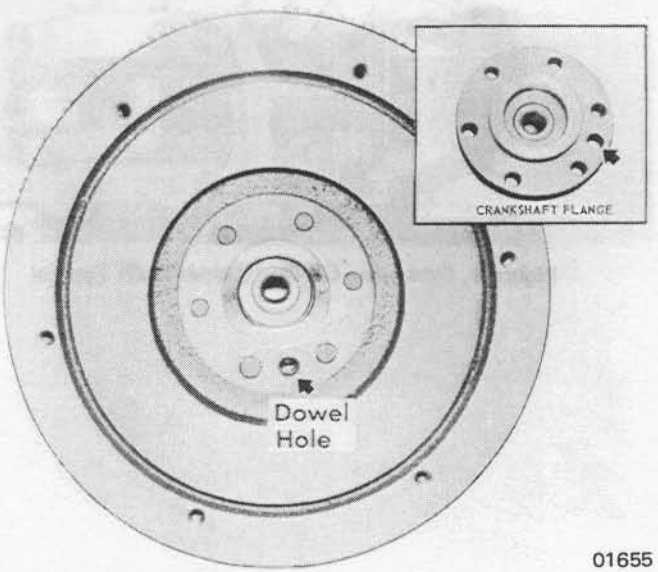


Figure 8. Flywheel Position on Crankshaft Flange

OIL SEAL (REAR MAIN)

REPLACEMENT

Rear main bearing oil seal can be replaced (both halves) without removing crankshaft.

NOTE: Always replace upper and lower seal as a unit. Install with lip facing toward front of engine. Where seal has 2 lips, install lip with helix toward front of engine.

1. With oil pan removed, remove rear main bearing cap.
2. Remove oil seal from rear main bearing cap by prying from bottom with small screwdriver.

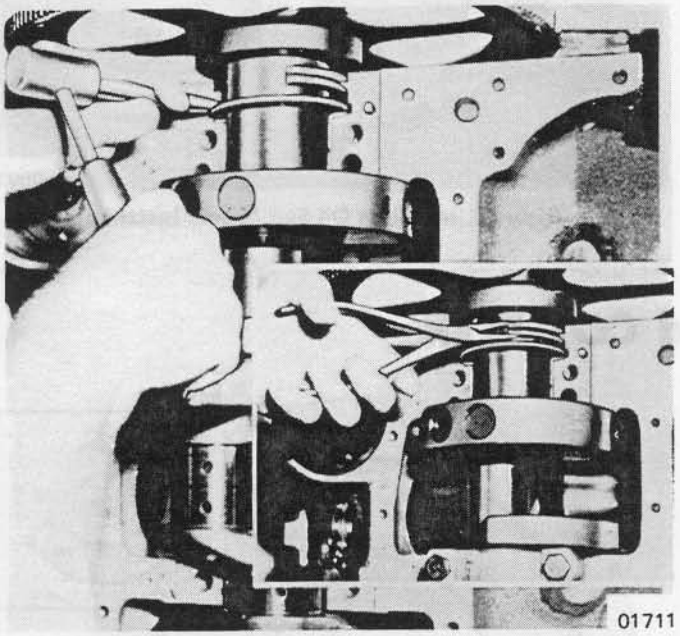


Figure 9. Removing Oil Seal (Upper Half) Typical

3. Lubricate lip of new seal with engine oil. Keep oil off parting line surface, as this is treated with glue. Insert seal in cap and roll seal into place with finger and thumb, using light pressure so seal tangs at parting line do not cut bead on back of seal.
4. To remove upper half of seal, use small hammer and tap brass pin punch on one end of seal until it protrudes far enough to be removed with pliers. (Figure 9)

   NOTE: Always wipe crankshaft surface clean before installing new seal.

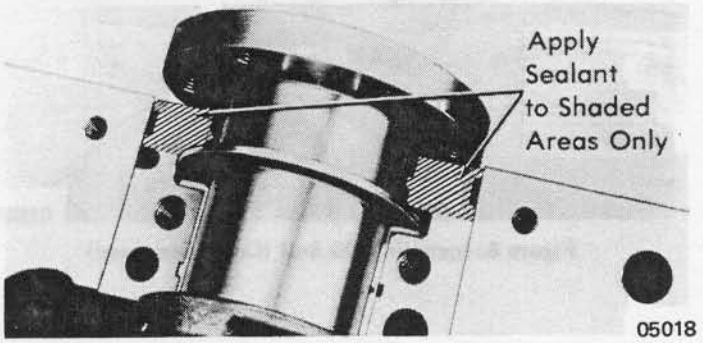


Figure 10. Sealing Bearing Cap and Block

5. Lubricate lip of new seal with engine oil. Keep oil off parting line surface. Gradually push with a hammer handle (while turning crankshaft) until seal is rolled into place (similar to installing a main bearing). Be careful that seal tangs at parting line do not cut bead on back of seal. Use sealer at parting line on rear main bearing cap half of seal.
6. Apply Perfect Seal No. 4 (C-92-34227) to cylinder block in seal area. (Figure 10)
7. Install rear main bearing cap (with new seal) and torque to specifications.
8. Install oil pan as outlined.

MAIN BEARINGS

1. Main bearings are precision insert type and do not utilize shim for adjustment. If clearances are found to be excessive, a new bearing (both upper and lower halves) will be required. Bearings are available in standard size and .001", .002", .010", and .020" undersize. (1" = 25.4mm)
2. Selective fitting of both rod and main bearing inserts is necessary in production to obtain close tolerances. For example, one half of a standard insert with one half of a .001" undersize insert may be found, which will decrease clearance .0005" from using a full standard bearing.
3. When a production crankshaft cannot be precision fitted by this method, it then is ground .009" undersize on main journals only. A .009" undersize bearing and .010" undersize bearing may be used for precision fitting in same manner as previously described. Any engine, fitted with a .009" undersize crankshaft, will be identified by following markings.
   - ".009" will be stamped on crankshaft counterweight forward of center main journal.
   - No. "9" will be stamped on block at left front oil pan rail.

INSPECTION

In general (except No. 1 bearing), lower half of bearing shows greater wear and most distress from fatigue. If, upon inspection, lower half is acceptable, it can be assumed that upper half also is satisfactory. If lower half shows evidence of wear or damage, replace both upper and lower halves. Never replace one half without replacing other half. Typical bearing failures are shown in Figure 1, following.

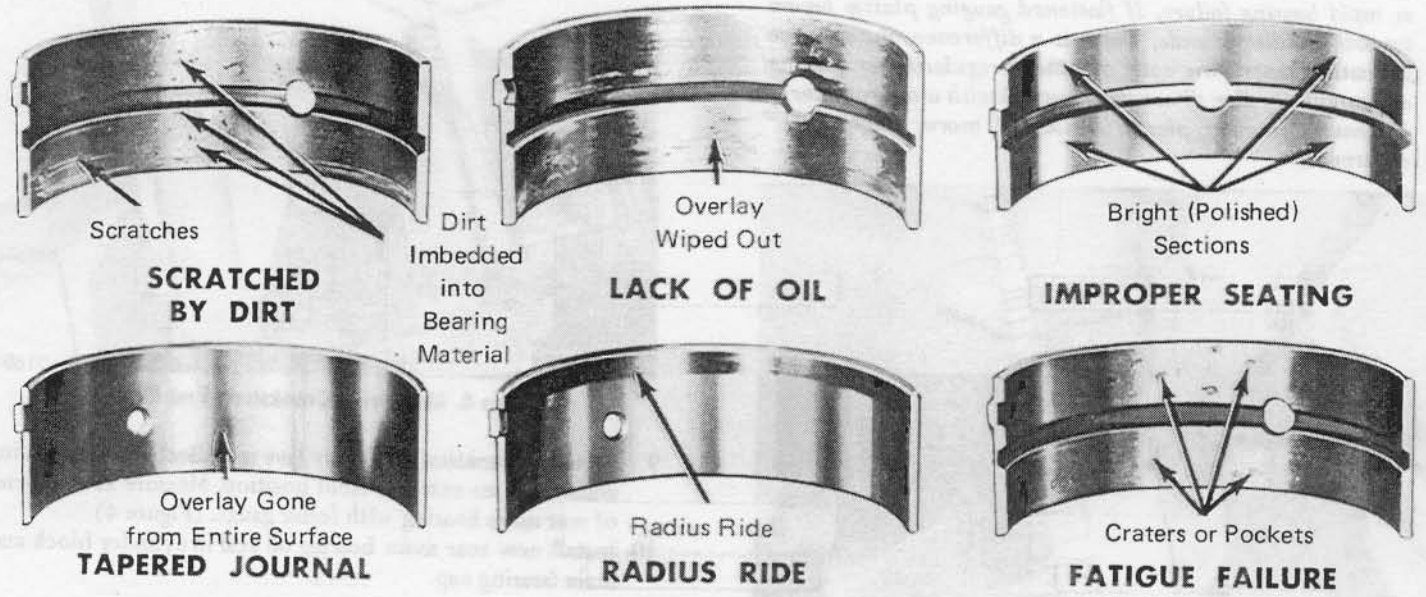
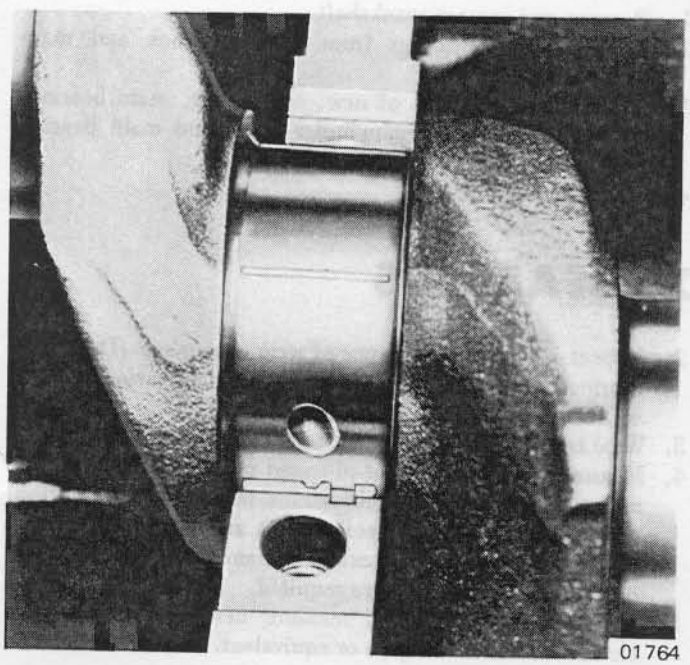


Figure 1. Typical Bearing Failure



CHECKING CLEARANCE

To obtain most accurate results, use Plastigage (or its equivalent), a wax-like plastic material which will compress evenly between bearing and journal surfaces without damaging either surface.

With engine upside down, crankshaft will rest on upper bearings, and total clearance can be measured between lower bearing and journal.

NOTE: To assure proper seating of crankshaft, torque all bearing cap bolts as specified. In addition, before checking fit of bearings, wipe surface of crankshaft journal and face and back of bearing clean of oil.

1. With oil pan and oil pump removed, and starting with rear main bearing, remove bearing cap and wipe oil from journal and bearing cap.
2. Place piece of gauging plastic the full width of bearing (parallel to crankshaft) on journal. (Figure 2)

Figure 2. Gauging Plastic on Journal

CAUTION: Do not rotate crankshaft while the gauging plastic is between bearing and journal.

3. Install bearing cap and evenly torque retaining bolts to specifications.
4. Remove bearing cap. Flattened gauging plastic will be found adhering to either bearing shell or journal.
5. A graduated scale (correlated in thousandths of an inch) exists on edge of gauging plastic envelope. Without removing gauging plastic, measure its compressed width (at widest point) with graduations on gauging plastic envelope. (Figure 3)

NOTE: Normally, main bearing journals wear evenly and are not out-of-round. However, if a bearing is being fitted to an out-of-round journal (.001" [.025mm] max.), be sure to fit to maximum diameter of journal. If bearing is fitted to minimum diameter, and journal is out-of-round .001", interference between bearing and journal will result in rapid bearing failure. If flattened gauging plastic tapers toward middle or ends, there is a difference in clearance indicating taper, low spot or other irregularity of bearing or journal. Be sure to measure journal with a micrometer if flattened gauging plastic indicates more than .001" difference.

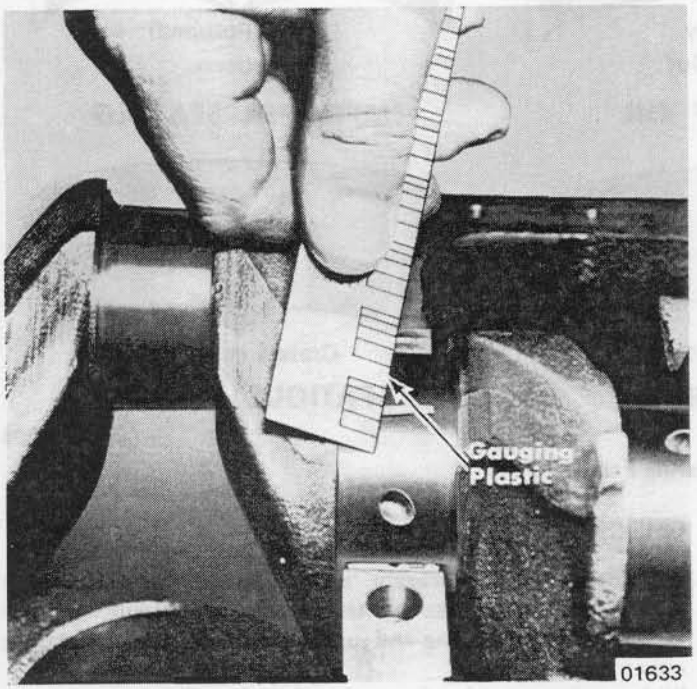


Figure 3. Measuring Gauging Plastic

6. If bearing clearance is within specifications, bearing insert is satisfactory. If clearance is not within specifications, replace insert. Always replace both upper and lower insert as a unit.
7. A standard .001" (.025mm) or .002" (.051mm) undersize bearing may produce proper clearance. If not, regrind crankshaft journal for use with next undersize bearing.
8. Proceed to next bearing. After all bearings have been checked, rotate crankshaft so that no excessive drag exists.

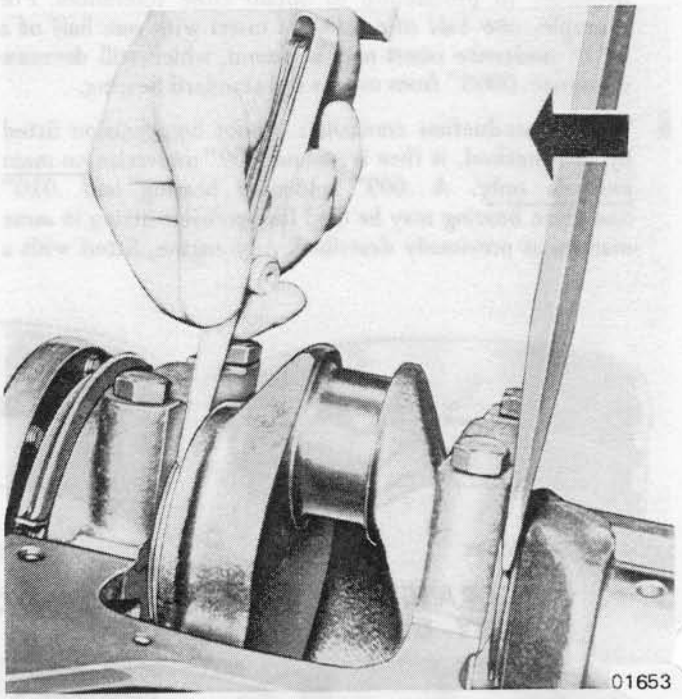


Figure 4. Measuring Crankshaft End Play

9. Measure crankshaft end play (see specifications) by forcing crankshaft to extreme front position. Measure at front end of rear main bearing with feeler gauge. (Figure 4)
10. Install new rear main bearing oil seal in cylinder block and main bearing cap.

MAIN BEARING REPLACEMENT

1. Remove and inspect crankshaft.
2. Remove main bearings from cylinder block and main bearing caps.
3. Coat bearing surfaces of new, correct-size, main bearings with oil and install in cylinder block and main bearing caps. Check clearance outlined.
4. Install crankshaft.

CONNECTING ROD BEARINGS

Connecting rod bearings are precision insert type and do not utilize shims for adjustment. DO NOT FILE RODS OR ROD CAPS. If clearances are found to be excessive, a new bearing will be required. Bearings are available in standard size and .001" and .002" undersize for use with new and used standard size crankshaft and in .010" and .020" undersize for use with reconditioned crankshafts. (1" = 25.4mm)

INSPECTION and REPLACEMENT

1. With oil pan and oil pump removed, remove connecting rod cap and bearing.
2. Inspect bearing for evidence of wear or damage. (Defective bearings should not be installed.) Typical bearing failures are shown in Figure 1, preceding.
3. Wipe bearings and crankpin clean of oil.
4. Measure crankpin for out-of-round or taper with a micrometer. If not within specifications, replace or recondition crankshaft. If within specifications and new bearing is to be installed, measure maximum diameter of crankpin to determine new bearing size required.
5. If within specifications, measure new or used bearing clearances with Plastigage or equivalent.

NOTE: If bearing is being fitted to out-of-round crankpin, be sure to fit maximum diameter of crankpin. If bearing is fitted to minimum diameter, and crankpin is out-of-round .001", interference between bearing and crankpin will result in rapid bearing failure.

a. Place a piece of gauging plastic the full width of crankpin (parallel to crankshaft). (Figure 5)
b. Install bearing connecting rod and cap.
c. Install bearing cap and torque nuts evenly to specifications.

CAUTION: Do not turn crankshaft with gauging plastic installed.

d. Remove bearing cap and, using scale on gauging plastic envelope, measure gauging plastic width at widest point. (Figure 6)

6. If clearance exceeds specifications, select a new, correct-size bearing and remeasure clearance.
7. Coat bearing surface with oil, install rod cap and torque nuts to specifications.

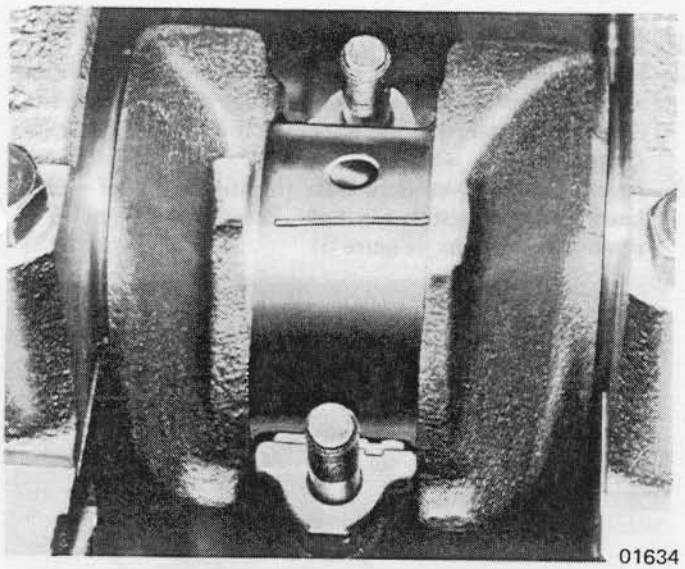


Figure 5. Gauging Plastic on Crankpin

8. When all connecting rod bearings have been installed, tap each rod lightly (parallel to crankpin) to be sure they have clearance.
9. Measure all connecting rod side clearances (see specifications) between connecting rod and side of crankpin. (Figure 7)

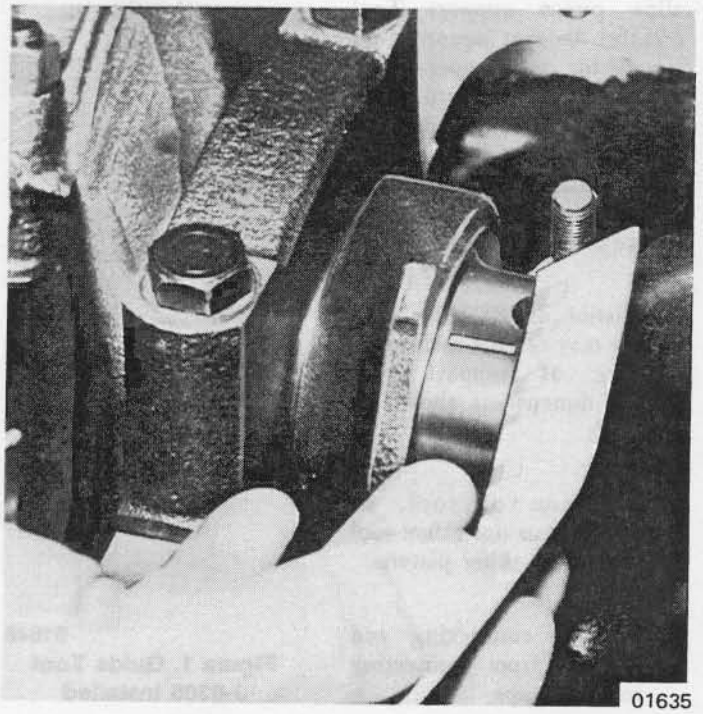


Figure 6. Measuring Gauging Plastic

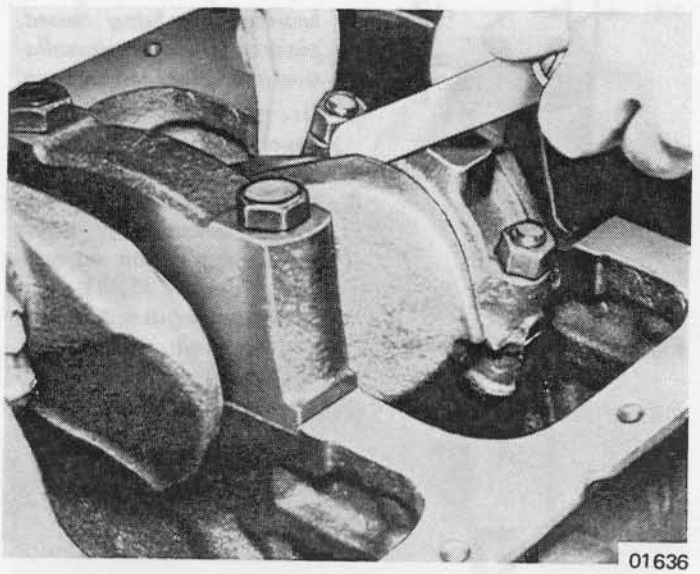


Figure 7. Measuring Connecting Rod Side Clearance

CONNECTING ROD and PISTON ASSEMBLIES

REMOVAL

1. With oil pan, oil pump and cylinder head removed, use a ridge reamer to remove any ridge and/or deposits from upper end of cylinder bore.

NOTE: Before ridge and/or deposits are removed, turn crankshaft until piston is at bottom of stroke and place a cloth on top of piston to collect cuttings. After ridge and/or deposits are removed, turn crankshaft until piston is at top of stroke and remove cloth and cuttings.

2. Inspect connecting rods and connecting rod caps for cylinder identification. If necessary, mark them.
3. Remove connecting rod cap and install Tool J-6305 (11/32") on bolts. (Figure 1) Push connecting rod and piston assembly out of top of cylinder block.

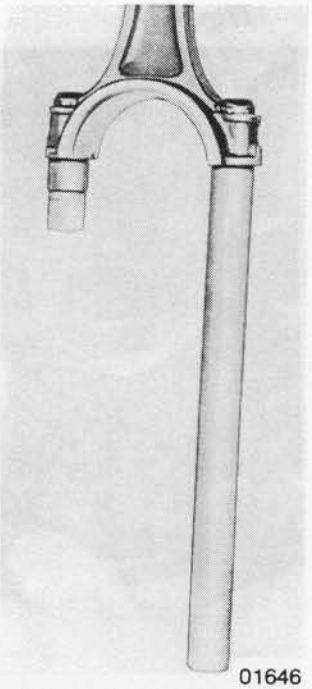
NOTE: It will be necessary to turn crankshaft slightly to disconnect some connecting rod and piston assemblies.

DISASSEMBLY (METHOD "1")

If bosses on pistons do not allow piston support Tool J-9510-1 to seat squarely on piston for press operations, modifications to tool are necessary. To allow adequate clearance for these bosses, turn or grind upper portion of tool to dimensions shown in Figure 2.

Installation of 181 cubic inch pistons may require additional grinding of support tool beyond dimensions shown in Figure 2.

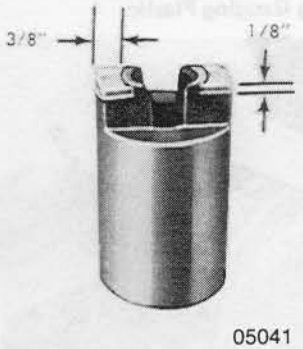
Modification of tool, as described, does not affect tool application on other pistons.



01646

Figure 1. Guide Tool J-6305 Installed

1. Remove connecting rod bearings from connecting rods and caps.



05041

Figure 2. Piston Support Tool J-9510-1

NOTE: If connecting rod bearings are being reused, place in a rack for reinstallation in original rod and cap.

2. Use piston ring expander to expand rings and remove from pistons.
3. Place connecting rod and piston assembly in arbor press with piston on support Tool J-9510-1 and press piston pin out of connecting rod and piston. (Figure 3)

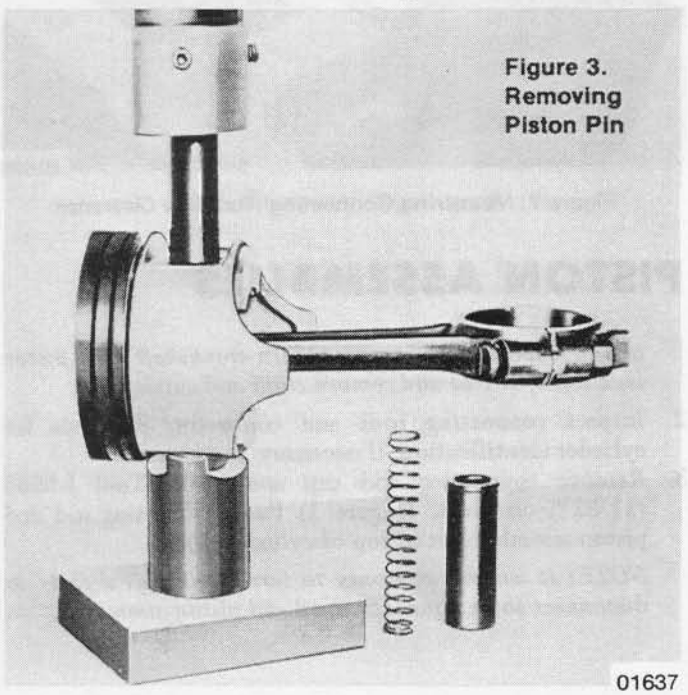
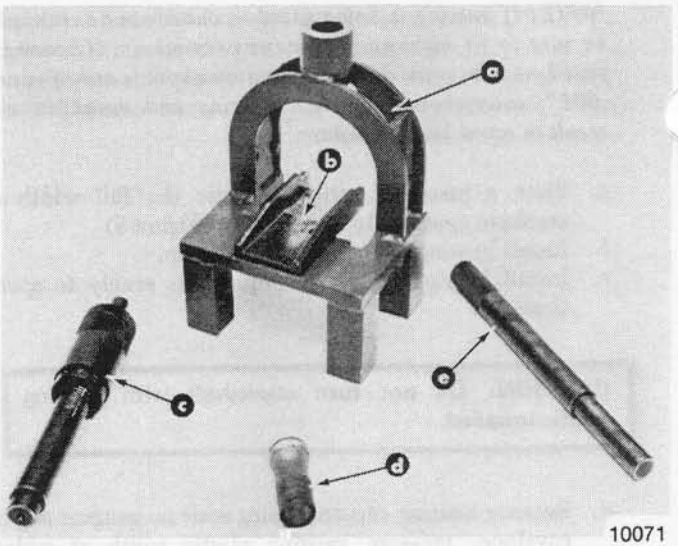


Figure 3. Removing Piston Pin

01637



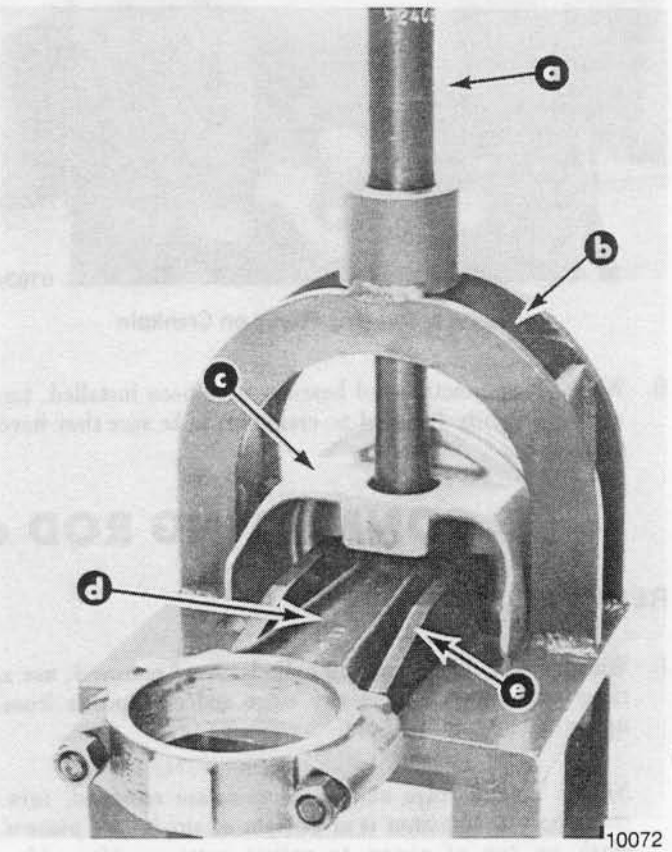
10071

a - Arched Base
b - Rod Support
c - Adjustable Installer
d - Piston Pin Guide
e - Piston Pin Remover

Figure 4. Tool (J-24086-100) Parts Identification

DISASSEMBLY (METHOD "2")

1. Use Tool Kit (J-24086-100), shown in Figure 4.
2. Position connecting rod onto tool rod support with rod support inserted between connecting rod end and piston. Align piston pin with hole located in top of arched base. (Figure 5)
3. Insert pin remover thru hole (located in top of arched base) and into piston pin hole. Press on pin remover to remove piston pin. (Figure 5)



10072

a - Piston Pin Remover
b - Arched Base
c - Piston
d - Connecting Rod
e - Rod Support

Figure 5. Removing Piston Pin

CLEANING and INSPECTION

Connecting Rods

1. Wash connecting rods in cleaning solvent and dry with compressed air.
2. Check for twisted or bent rods and inspect for nicks or cracks. Replace damaged connecting rods.

Pistons

1. Clean varnish from piston skirts and pins with cleaning solvent. DO NOT WIRE BRUSH ANY PART OF PISTON. Clean ring grooves with groove cleaner and make sure oil ring holes and slots are clean.
2. Inspect piston for cracked ring lands, skirts or pin bosses, wavy worn ring lands, scuffed or damaged skirts and eroded areas at top of piston. Replace pistons which are damaged or show signs of excessive wear.
3. Inspect grooves for nicks or burrs which might cause rings to hang up.
4. Measure piston skirt (across centerline of piston pin) and check clearance as outlined under "Piston Selection".

Piston Pins

1. Piston and piston pin are a matched set and not serviced separately.

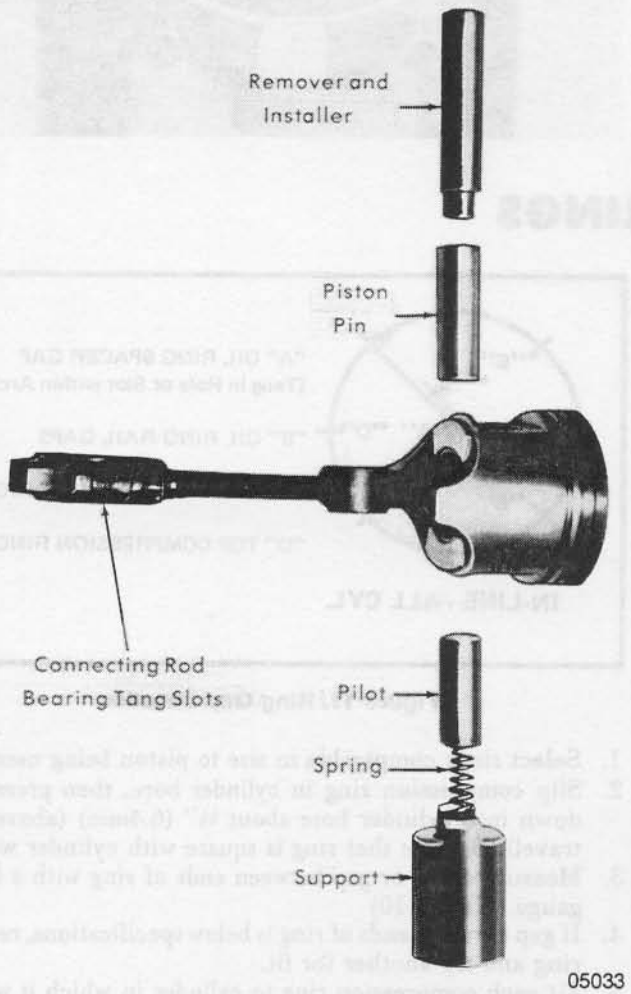


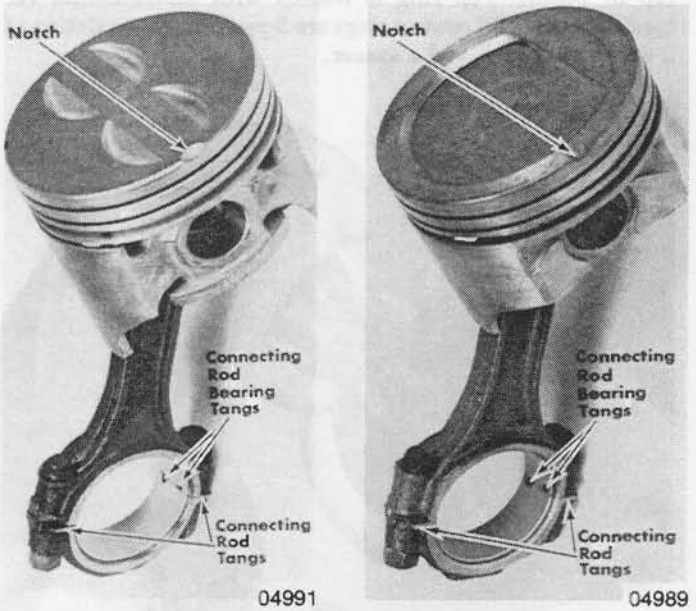
Figure 6. Piston Pin Installation

Figure 7. Connecting Rod and Oven

2. Pin bores and piston pins must be free of varnish or scuffing. Measure piston pin with a micrometer and piston pin bore with a dial bore gauge or inside micrometer. If clearance is in excess of .001" (.025mm) wear limit, replace piston and piston pin assembly.

REASSEMBLY (METHOD "1")

CAUTION: DO NOT oil piston pin or connecting rod (Figure 6) before rod end is to be heated for installation.



Model 153 Cu. In. **Models 181 and 250 Cu. In.**

Figure 8. Connecting Rod and Piston Assembly

1. Heat piston pin end of connecting rod.

   NOTE: An oven is recommended to heat piston pin end of connecting rod prior to piston installation. (Figure 7)

2. Place support Tool J-9510-1 with spring and pilot in place on arbor press.
3. Position piston on connecting rod with notched side of piston (Figure 8) and connecting rod tangs aligned.
4. Place piston on support, indexing pilot through piston and rod.
5. Place installer (Figure 6) on piston pin, start piston pin and press on installer until pilot bottoms in support.
6. Remove installer from connecting rod and piston assembly and check piston for freedom of movement on piston pin.
7. Allow connecting rod and piston assembly to cool, then oil piston pin.

REASSEMBLY (METHOD "2")

1. Lubricate piston pin, piston pin hole in piston and hole in rod end with a light coat of engine oil.
2. Position rod onto rod support and piston onto rod end. Insert piston pin guide thru bottom piston pin hole and into connecting rod. Place piston pin thru top side of piston. (Figure 9)
3. Adjust adjustable installer to setting specified on chart (which came with tool) for particular piston installation. Lock adjustable installer with jam nut.
4. Insert adjustable installer thru hole (located on top of arched base) and into piston pin hole. Carefully press on adjustable installer until installer bottoms-out on arched base to install piston pin.

a - Jam Nut
b - Adjustable Installer
c - Arched Base
d - Piston
e - Connecting Rod
f - Piston Pin
g - Rod Support

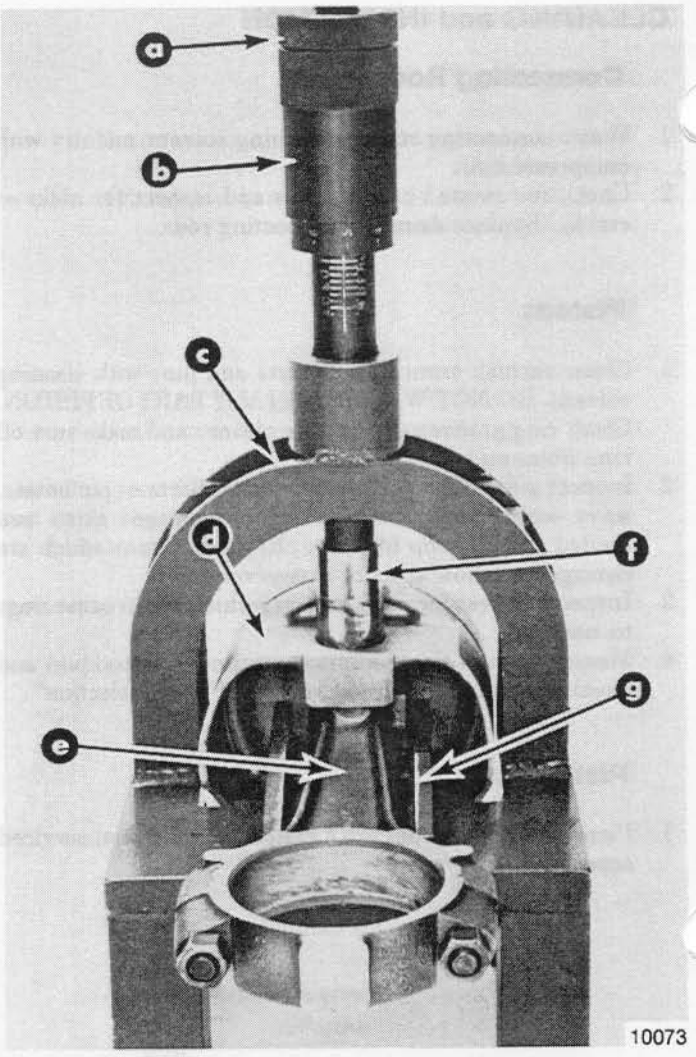


Figure 9. Installing Piston Pin

PISTON RINGS

All compression rings are marked on upper side of ring. When installing compression rings, make sure marked side is toward top of piston. Top ring is treated with molybdenum for maximum life. Oil control rings are 3-piece type, consisting of 2 segments (rails) and a spacer.

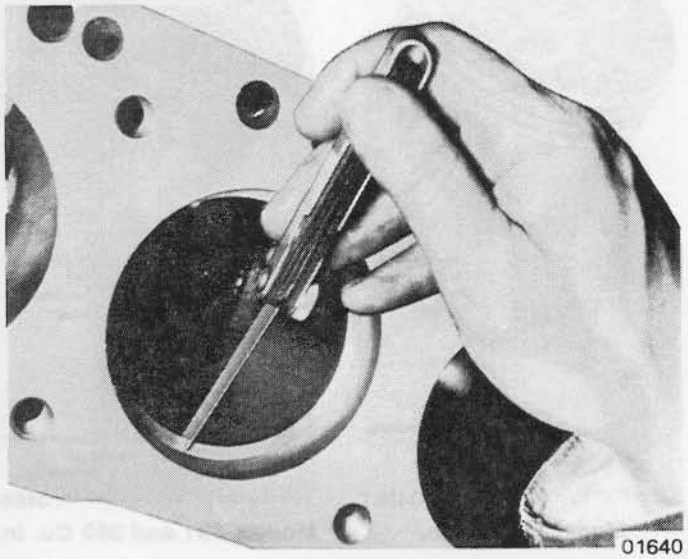


Figure 10. Measuring Ring Gap

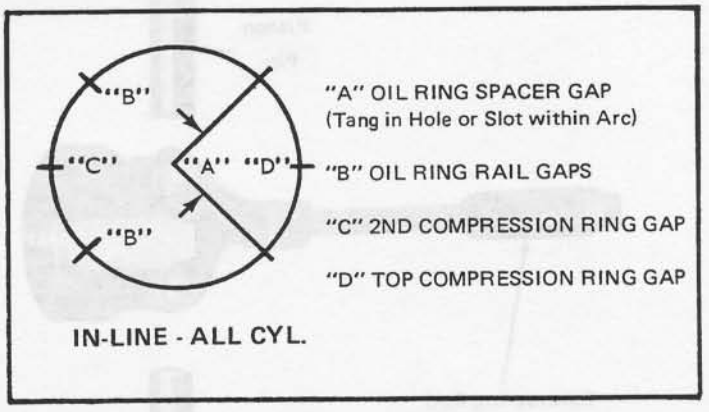


Figure 11. Ring Gap Location

1. Select rings comparable in size to piston being used.
2. Slip compression ring in cylinder bore, then press ring down into cylinder bore about ¼" (6.4mm) (above ring travel). Be sure that ring is square with cylinder wall.
3. Measure space or gap between ends of ring with a feeler gauge. (Figure 10)
4. If gap between ends of ring is below specifications, remove ring and try another for fit.
5. Fit each compression ring to cylinder in which it will be used.

6. Clean and inspect pistons, as previously outlined, if not already completed.
7. Slip outer surface of top and second compression ring into respective piston ring groove and roll ring entirely around groove (Figure 12) to make sure that ring is free. If binding occurs at any point, determine cause and, if caused by ring groove, remove by dressing with a fine cut file. If binding is caused by a distorted ring, use a new ring.
8. Install piston rings as shown in Figure 11. Ring installation tools are:

Model Engine Displacement (Cu. In.)	Tool No.
153,250 181	J-8021 (3-7/8") J-8032 (4")

   a. Install oil ring spacer in groove and (except on 250) insert anti-rotation tang in oil hole.
   b. Hold spacer ends butted and install lower steel oil ring rail with gap properly located. (Figure 11)
   c. Install upper steel oil ring rail with gap properly located.
   d. Flex oil ring assembly to make sure that ring is free. If binding occurs at any point, determine cause and, if caused by ring groove, remove by dressing groove with a fine cut file. If binding is caused by a distorted ring, use a new ring.
   e. Install second compression ring expander, then ring with gaps properly located.
   f. Install top compression ring with gap in correct location.
9. Proper clearance of piston ring in piston ring groove is necessary for proper ring action and to reduce wear. Therefore, when fitting new rings, measure clearances between ring surfaces and groove. (See "Specifications" Section 8.)

INSTALLATION

NOTE: Cylinder bores must be clean before piston installation. Clean with hot water and detergent wash or with a light honing, as necessary. After cleaning, swab bores several times with light engine oil and a clean cloth.

1. Lubricate connecting rod bearings and install in rods and rod caps.
2. Lightly coat pistons, rings and cylinder walls with light engine oil.
3. With bearing caps removed, install Tool J-6305 (11/32") on connecting rod bolts.

CAUTION: Be sure that ring gaps are properly positioned as previously outlined.

NOTE: Early Model "181", No. 2 connecting rods have a ground recess on camshaft side to provide clearance for fuel pump lobe on camshaft. Be sure that No. 2 connecting rod is installed in same location and position. If connecting rod is replaced, then replace camshaft also, since replacement connecting rods are not ground for clearance, and replacement camshafts have a smaller fuel pump lobe.

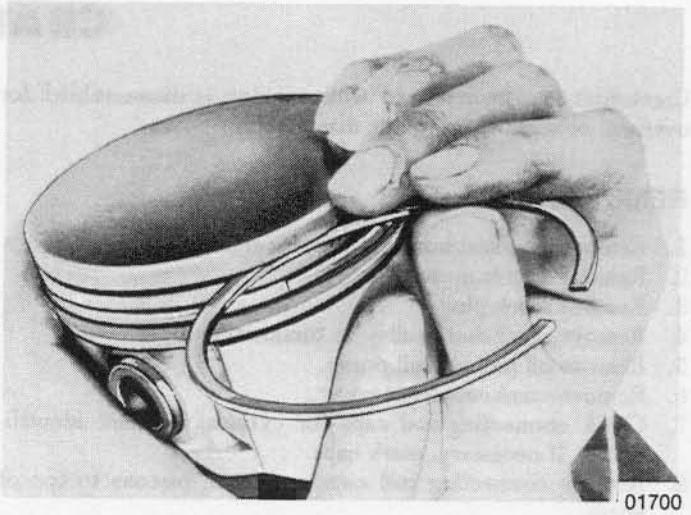


Figure 12. Checking Ring in Groove

4. Install each connecting rod and piston assembly in respective bore. Pistons must have piston notch facing front of engine. Use Tool J-8307 to compress rings. (Figure 13) Guide connecting rod into place on crankshaft journal with Tool J-5239. Use light blows with hammer handle to install piston into bore. Hold ring compressor firmly against cylinder block until all piston rings have entered cylinder bore.
5. Remove guide tool.
6. Install bearing caps and torque nuts to specification.

NOTE: If bearing replacement is required, refer to "Connecting Rod Bearings", preceding.

NOTE: Be sure to install new pistons in same cylinders for which they were fitted and used pistons in same cylinders from which they were removed. Each connecting rod and bearing cap should be marked, beginning at front of engine.

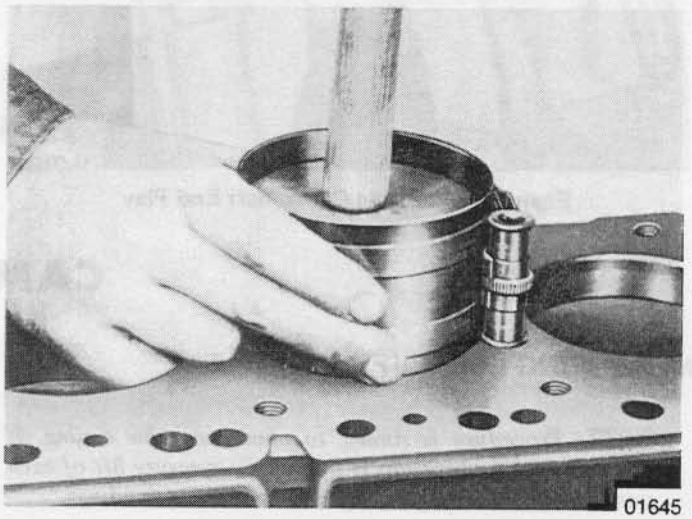


Figure 13. Installing Connecting Rod and Piston Assemblies

CRANKSHAFT

Crankshaft can be removed while engine is disassembled for overhaul or without complete disassembly.

REMOVAL

1. Remove flywheel housing, coupler and flywheel.
2. Remove starter motor.
3. Remove spark plugs.
4. Remove crankshaft pulley or torsional damper.
5. Remove oil pan and oil pump.
6. Remove crankcase front cover.
7. Check connecting rod caps for cylinder number identification. If necessary, mark caps.
8. Remove connecting rod caps and push pistons to top of bores.
9. Remove main bearing caps and lift crankshaft out of cylinder block.
10. Remove rear main bearing oil seal and main bearings from cylinder block and main bearing caps.

CLEANING and INSPECTION

1. Wash crankshaft in solvent and dry with compressed air.

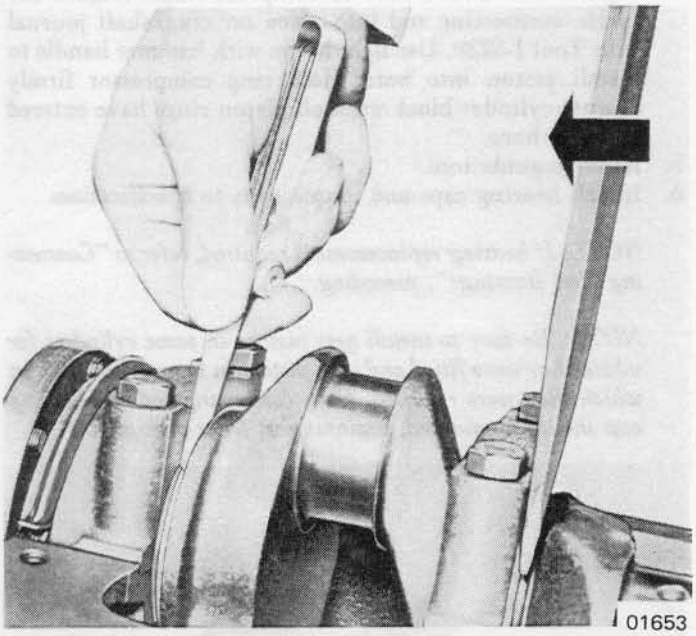


Figure 1. Measuring Crankshaft End Play

2. Measure dimensions of main bearing journals and crankpins with a micrometer for out-of-round, taper or undersize (see "Specifications" Section 8).
3. Check crankshaft for run-out by supporting at front and rear main bearing journals in "V" blocks and check at front and rear intermediate journals with a dial indicator (see "Specifications").
4. Replace or recondition crankshaft if not within specifications.

INSTALLATION

1. Install crankshaft as follows:
   a. Install rear main bearing oil seal in cylinder block and rear main bearing cap grooves. Install with lip of seal toward front of engine.
   b. Lubricate lip of seal with engine oil. Keep oil off parting line surface.
   c. Install main bearings in cylinder block and main bearing caps, then lubricate bearing surface with engine oil.
   d. Install crankshaft, being careful not to damage bearing surfaces.
   e. Apply a thin coat of brush-on type oil sealing compound to block mating surface and corresponding surface of cap only. Do not allow sealer on crankshaft or seal lip.
   f. Install main bearing caps with arrows pointing toward front of engine.
   g. Torque all except rear main bearing cap bolts to 10-12 ft. lbs. (1.38 to 1.66mkg). Torque rear main bearing cap bolts to specifications, then tap end of crankshaft, first from rear then forward, with a lead hammer. This will line up rear main bearing and crankshaft thrust surfaces. Retorque all main bearing cap bolts to specifications.
   h. Measure crankshaft end play with a feeler gauge. Force crankshaft forward and measure clearance between front of rear main bearing and crankshaft thrust surface. (Figure 1)
2. Install connecting rod and caps as outlined.
3. Install crankcase front cover as indicated.
4. Install oil pump and oil pan as outlined.
5. Install crankshaft pulley or torsional damper as indicated.
6. Install starter motor.
7. Install flywheel, coupler and flywheel housing as outlined.
8. Install spark plugs and torque to specifications.

CAMSHAFT

MEASURING LOBE LIFT

NOTE: Procedure is similar to checking valve timing. If improper valve operation is indicated, measure lift of each push rod in consecutive order and record the readings.

1. Remove valve mechanism as outlined.
2. Position indicator with ball socket adaptor (Tool J-8520) on push rod. (Figure 2)
3. Rotate torsional damper slowly in direction of rotation until lifter is on lowest position of cam lobe.
4. Set dial indicator on zero, then rotate damper slowly, or attach an auxiliary starter switch and "bump" engine over, until push rod is in fully raised position.
5. Compare total lift recorded from dial indicator with "Specifications", Section 8.
6. Continue to rotate crankshaft until indicator reads zero. This will be a check on accuracy of original indicator reading.
7. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
8. Install and adjust valve mechanism as outlined.

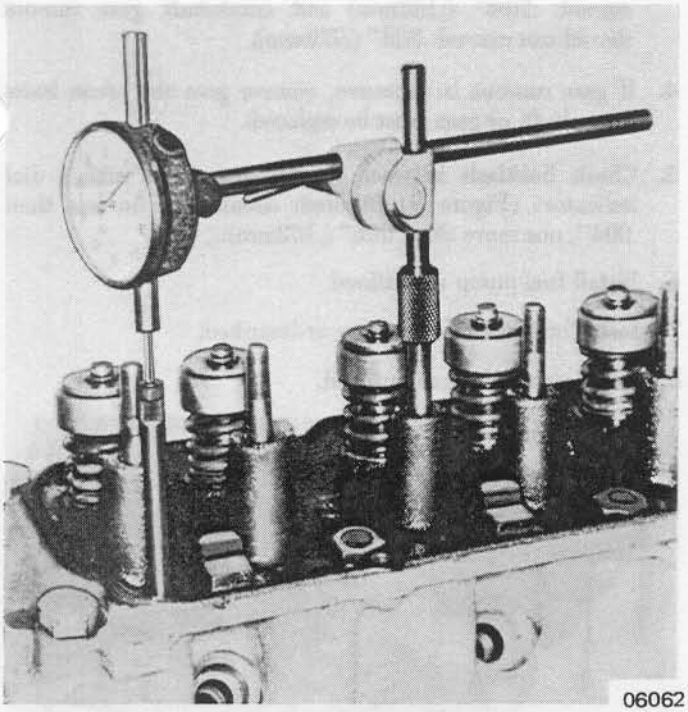


Figure 2. Measuring Camshaft Lobe Lift

REMOVAL

1. Remove valve lifters as outlined.
2. Remove crankcase front cover as outlined.
3. Remove fuel pump as outlined.
4. Align timing gear marks, then remove 2 camshaft thrust plate screws by working thru holes in camshaft gear. (Figure 3)
5. Pull camshaft and gear assembly out thru front of block.

NOTE: Support camshaft carefully when removing to protect camshaft bearings.

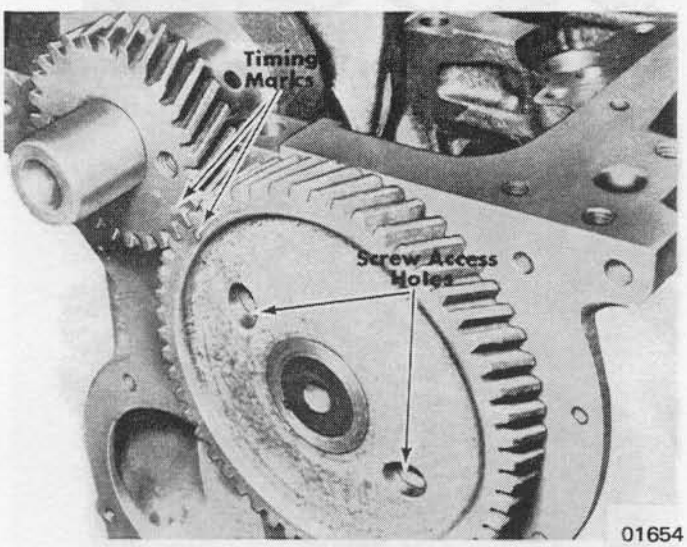


Figure 3. Timing Gear Marks

INSPECTION

1. Measure camshaft bearing journals with a micrometer for out-of-round condition. If journals exceed .001" (.025mm) out-of-round, replace camshaft.
2. Check camshaft for alignment with "V" blocks and dial indicator (Figure 4) for exact amount that camshaft is out-of-true. If out more than .002" (.051mm) dial indicator reading, replace camshaft.
3. On in-line engines, inspect camshaft gear and thrust plate for wear or damage. Measure camshaft end play (.001" to .005" [.025mm to .127mm]). (Figure 5)

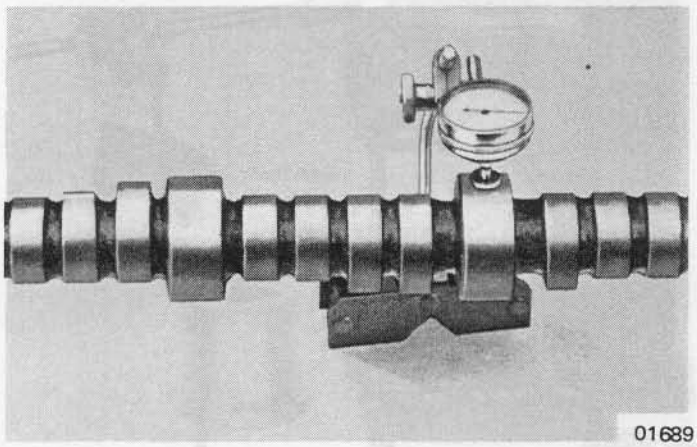


Figure 4. Checking Camshaft Alignment

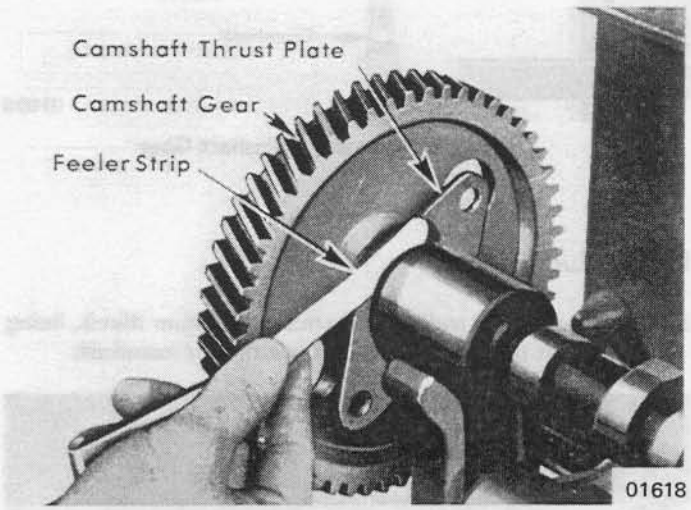


Figure 5. Measuring Camshaft End Play

CAMSHAFT GEAR REPLACEMENT

1. If inspection (preceding) indicated that camshaft, gear or thrust plate should be replaced, remove gear from camshaft with camshaft gear remover Tool J-971.
2. Place camshaft thru gear remover, place end of remover on table of a press and press shaft out of gear. (Figure 6)

CAUTION: Position thrust plate so that woodruff key in shaft does not damage plate when shaft is pressed out of gear. Also support hub of gear, or gear will be seriously damaged.

3. To assemble camshaft gear, thrust plate and gear spacer ring to camshaft, firmly support camshaft at back of front journal in arbor press.

4. Place gear spacer ring and thrust plate over end of shaft, and install woodruff key in shaft keyway. Press shaft gear onto shaft until it bottoms against gear spacer ring. End clearance of thrust plate should be .001" to .005" (.025mm to .127mm). (Figure 5)

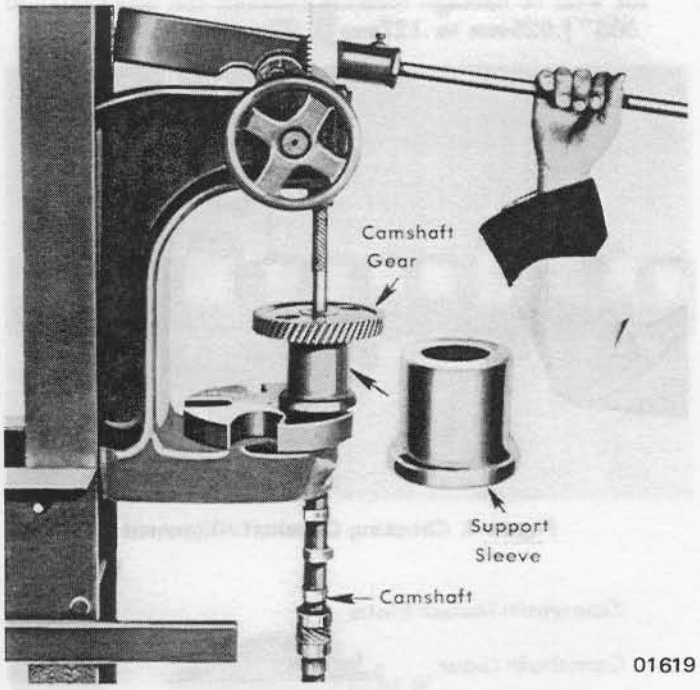


Figure 6. Removing Camshaft Gear

INSTALLATION

1. Install camshaft and gear assembly in engine block, being careful not to damage camshaft bearings or camshaft.

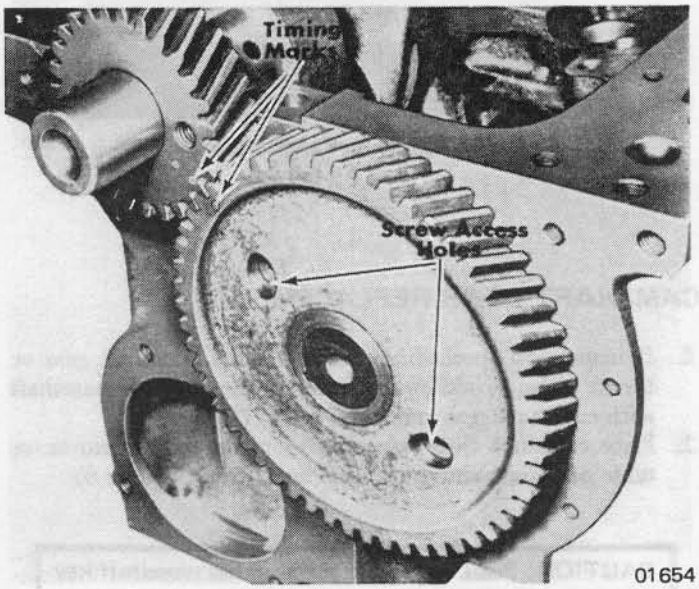


Figure 7. Crankshaft Gear

2. Turn crankshaft and camshaft so that timing marks on gear teeth will line up. (Figure 7) Push camshaft thrust plate to block screws and torque to specifications.
3. Check camshaft and crankshaft gear run-out with a dial indicator. (Figure 8) Camshaft gear run-out should not exceed .004" (.102mm) and crankshaft gear run-out should not exceed .003" (.076mm).
4. If gear run-out is excessive, remove gear and clean burrs from shaft, or gear must be replaced.
5. Check backlash between timing gear teeth with a dial indicator. (Figure 9) Backlash should not be less than .004", nor more than .006" (.152mm).
6. Install fuel pump as outlined.
7. Install crankcase front cover as described.
8. Install valve lifters as outlined.

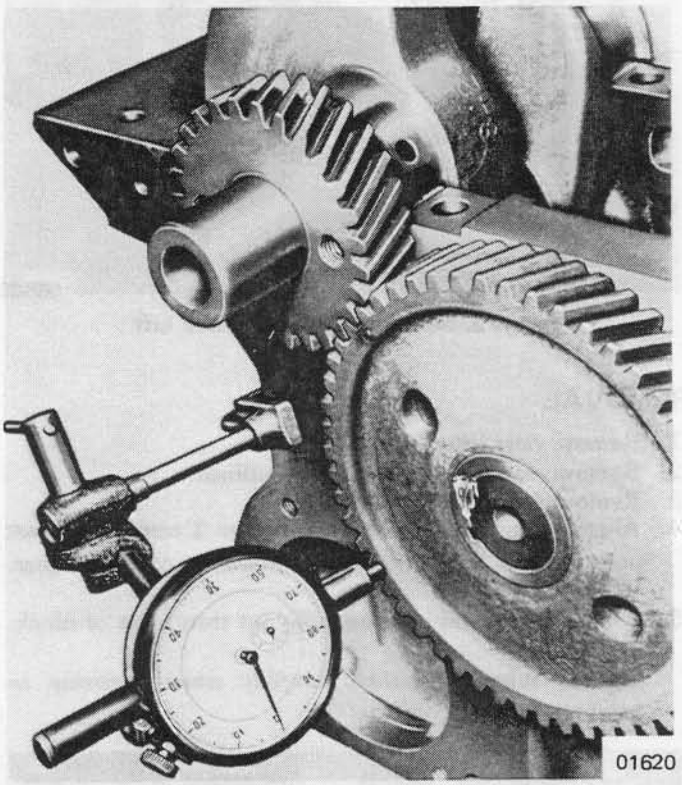


Figure 8. Checking Timing Gear Run-Out

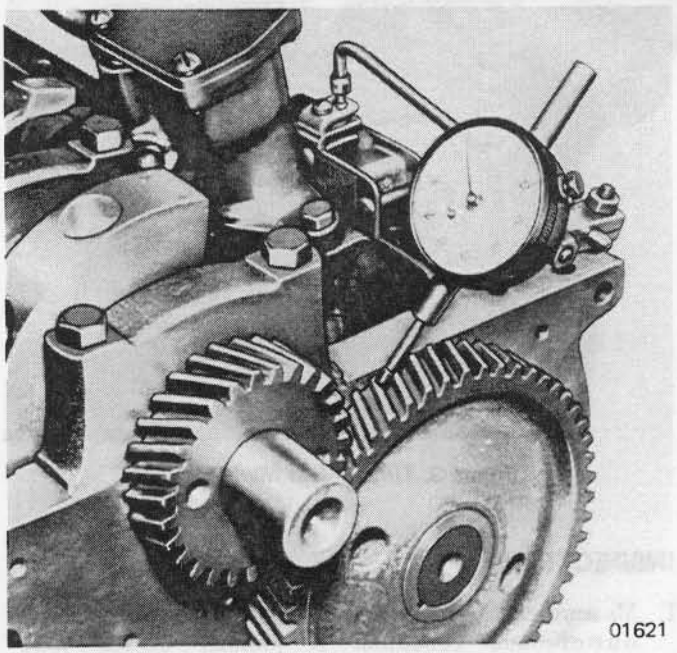


Figure 9. Checking Timing Gear Backlash

CAMSHAFT BEARINGS

REMOVAL

With camshaft removed, inspect bearings for evidence of wear or damage. Replace defective bearings.

Replace camshaft bearings while engine is disassembled for overhaul or without complete disassembly of the engine. To replace bearings without complete disassembly, remove camshaft and crankshaft, leaving cylinder heads attached and pistons in place. Before removing crankshaft, tape threads of connecting rod bolts to prevent damage to crankshaft. Fasten connecting rods against sides of engine so that rods will not hinder camshaft bearing replacement.

1. With camshaft and crankshaft removed, drive camshaft rear plug from cylinder block.

   NOTE: This procedure is based on removal of bearings nearest center of engine first. Thus, a minimum number of turns are necessary to remove all bearings.

2. Using Tool Set J-6098, with nut and thrust washer installed to end of threads, position pilot in front camshaft bearing and install puller screw thru pilot.
3. Install remover and installer tool with shoulder toward bearing, making sure a sufficient amount of threads are engaged.
4. Using 2 wrenches, hold puller screw while turning nut. When bearing has been pulled from bore, remove tool and bearing from puller screw. (Figure 10)
5. Remove remaining bearings (except front and rear) in same manner. Position pilot in rear camshaft bearing to remove rear intermediate bearing.
6. Assemble remover and installer tool on driver handle and remove front and rear camshaft bearings by driving toward center of cylinder block. (Figure 11)

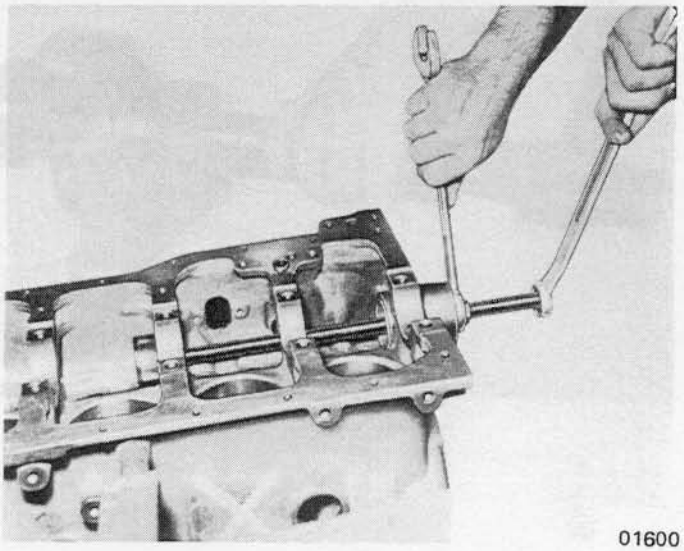


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Figure 10. Pulling Bearing from Bore

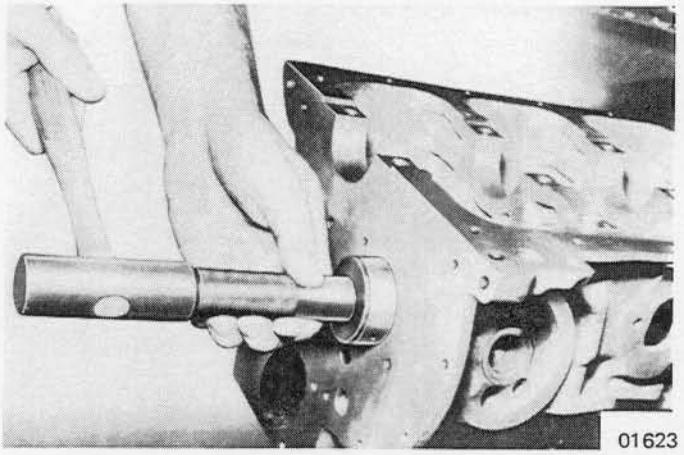

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Figure 11. Removing and Installing Camshaft Bearings

INSTALLATION

Install front and rear camshaft bearings first. These bearings will act as guides for pilot and center remaining bearings being pulled into place.

NOTE: Bearing O.D.'s for 6-cylinder (Nos. 1 and 4) and 4-cylinder (No. 3) are 2.009"-2.011" (51.03 to 51.08mm), and 6-cylinder (Nos. 2 and 3) and 4-cylinder (Nos. 1 and 2) are 1.999"-2.001" (50.77 to 50.83mm).

1. Assemble remover and installer tool on driver handle and install front and rear camshaft bearings by driving toward center of cylinder block. (Figure 11)

CAUTION: Oil holes in bearings must line up with oil holes in cylinder block. Oil hole is on top side of bearing shell and cannot be seen during installation, so first align bearing shell oil hole with oil hole in bore and mark opposite side of bearing and block at bore to easily position oil hole during installation.

NOTE: Front bearing must be driven approximately 1/8" (3.2mm) behind front of cylinder block to uncover oil hole to timing gear oil nozzle.

2. Using Tool Set J-6098, with nut and thrust washer installed to end of threads, position pilot in front camshaft bearing and install puller screw thru pilot.
3. Index camshaft bearing in bore, then install remover and installer tool on puller screw with shoulder toward bearings.
4. Using 2 wrenches, hold puller screw while turning nut. After bearing has been pulled into bore, remove tool from puller screw and check alignment of oil hole in camshaft bearing. (Figure 10)

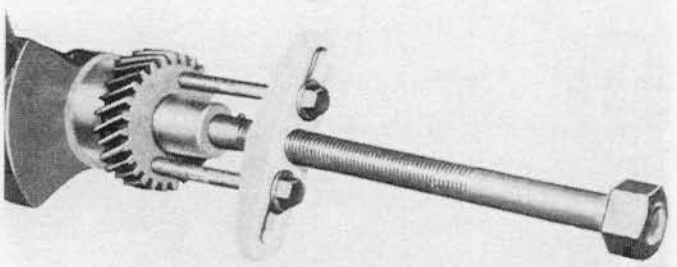

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Figure 12. Removing Crankshaft Gear

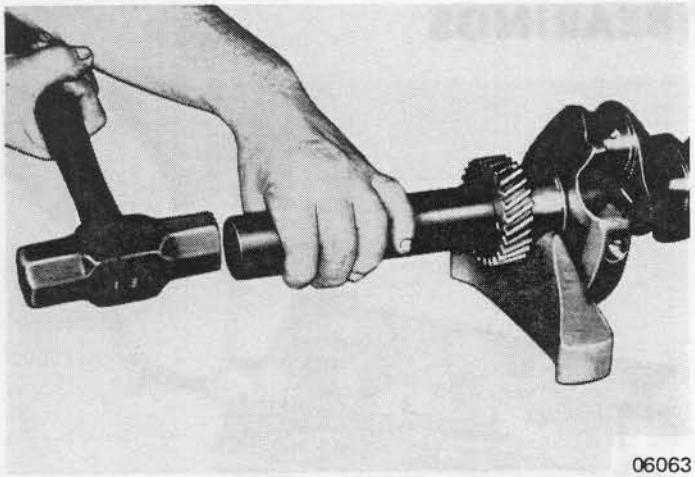

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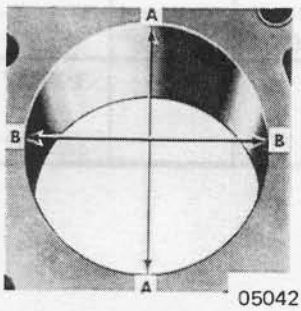
Figure 13. Installing Crankshaft Gear

5. Install remaining bearings in same manner. Position pilot in rear camshaft bearing to install rear intermediate bearing.
6. Install a new camshaft rear plug flush to 1/32" (.8mm) deep and parallel with rear surface of cylinder block. Us Perfect Seal No. 4 (C-92-34227) on plug.

CLEANING and INSPECTION

1. Wash cylinder block thoroughly in cleaning solvent and clean all gasket surfaces.
2. Remove oil gallery plugs and clean all oil passages.

NOTE: Remove plugs with a sharp punch or drill and pry out.



"A" = At Right Angle to Centerline of Engine
"B" = Parallel to Centerline of Engine
Taper = Difference between "A" Measurement at Top of Cylinder Bore and "A" Measurement at Bottom of Cylinder Bore
Out-of-Round = Difference between "A" and "B"

Figure 1. Cylinder Measurement

3. Clean and inspect water passages in cylinder block.
4. Inspect cylinder block for cracks in cylinder walls, water jacket valve lifter bores and main bearing webs.
5. Measure the cylinder walls for taper, out-of-round or excessive ridge at top of ring travel (Figure 1) with dial indicator. (Figure 2) Set gauge so that thrust pin must be forced in about ¼" (6.4mm) to enter gauge in cylinder bore. Center gauge in cylinder and turn dial to "O". Carefully work gauge up-and-down cylinder to determine taper and turn gauge to different points around cylinder wall to determine out-of-round condition. If cylinders exceed specifications, honing and/or boring are necessary. (Figure 2)

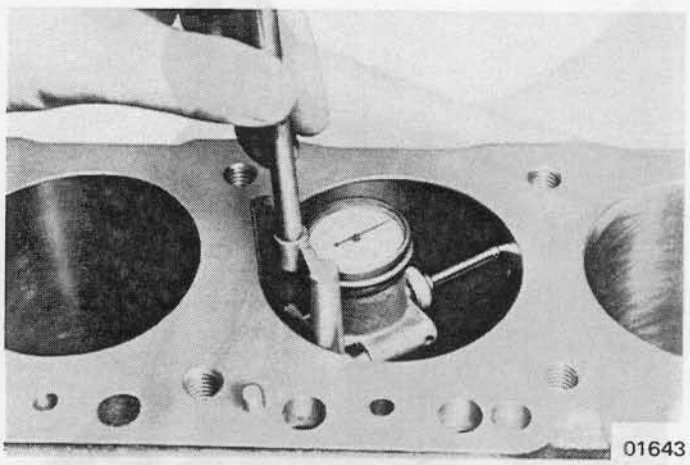


Figure 2. Measuring Cylinder Bore

REPAIRS

Cylinder Conditioning

Condition of engine at time of repair is important. If inspection indicates that cylinder block is acceptable, except for out-of-round or tapered cylinders, condition the block by honing or boring.

If cylinders have less than .005" (.127mm) taper or wear, condition them with a hone and fit with high limit, standard size piston. A cylinder bore of less than .005" wear or taper may not clean up entirely when fitted to a high limit piston. To clean up bore entirely, in such a case, rebore for an oversize piston. If more than .005" taper or wear, bore and hone to smallest oversize that permits complete resurfacing of all cylinders.

When pistons are fitted (honing not necessary), clean (scrub) cylinder bores with detergent and hot water. After cleaning, swab cylinder bores several times with light engine oil with clean cloth, then wipe with clean, dry cloth.

Cylinder Boring

1. Before using any type boring bar, file off top of cylinder block to remove dirt or burrs. This will guard against a tilted boring bar and assures that rebored cylinder wall is at right angles to crankshaft.
2. Measure piston, to be fitted, with a micrometer at center of piston skirt and at right angles to piston pin. Bore cylinder to same diameter as piston and hone cylinder to specifications (Section 8) and as outlined under "Cylinder Honing" and "Piston Selection", following.
3. Carefully follow instructions furnished by manufacturer of equipment being used.

Cylinder Honing

1. Follow hone manufacturer's recommendations for use of hone and cleaning and lubrication during honing.
2. Occasionally, during honing operation, thoroughly clean cylinder bore and check piston for correct fit in cylinder.
3. When finish honing a cylinder bore to fit a piston, move hone up-and-down to obtain very fine uniform surface finish marks in a cross-hatch pattern of approximately 30° to cylinder bore. Finish marks should be clean but not sharp and free from imbedded particles and torn or folded metal.

CAUTION: Handle pistons with care and do not attempt to force them thru cylinder until cylinder has been honed to correct size, as this type piston can be distorted thru careless handling.

4. Permanently mark piston for cylinder to which it has been fitted and proceed to hone cylinders and fit remaining pistons.
5. Thoroughly clean cylinder bores with hot water and detergent. Scrub well with a stiff bristle brush and rinse thoroughly with hot water. Be absolutely certain that no abrasive material is allowed to remain in cylinder bores, or it will rapidly wear new rings and cylinder bores in addition to bearings lubricated by contaminated oil. Swab bores several times with light engine oil with a clean cloth, then wipe with a clean, dry cloth. DO NOT clean cylinder with kerosene or gasoline. Clean remainder of cylinder block to remove excess material spread during honing operation.

PISTON SELECTION

1. Check USED piston to cylinder bore clearance as follows:
   a. Measure "Cylinder Bore Diameter" with a telescope gauge (2½" [63.5mm] from top of cylinder bore).
   b. Measure "Piston Diameter" (at skirt across center line of piston pin).
   c. Subtract piston diameter from cylinder bore diameter to determine "Piston to Bore Clearance".
   d. Determine if piston to bore clearance is in acceptable range. ("Specifications" Section 8)
2. If used piston is not acceptable, check "Oversize Pistons Available" chart, following, and determine if a new piston can be selected to fit cylinder bore within acceptable range.
3. If cylinder bore must be reconditioned, measure new piston diameter (across centerline of piston pin), then hone cylinder bore to correct clearance.
4. Mark piston to identify cylinder for which it was fitted.

OVERSIZE PISTONS AVAILABLE

Model Engine Displacement (Cu. In.)	Piston Size			
	.001"	.005"	.020"	.030"
153, 230 and 250	3.8760" to 3.8770"			3.9037" to 3.9059"
181	3.9963" to 3.9973"	3.8937" to 3.8957"	4.0138" to 4.0158"	
292	3.8740" to 3.8750"			3.9038" to 3.9058"

Metric Conversion: 1" = 25.4mm

DISTRIBUTOR LOWER BUSHING INSPECTION and REPLACEMENT

Distributor lower bearing is a bronze bushing pressed into lower side of engine block. Its upper inside diameter pilots distributor shaft, and outside diameter (extending below block) pilots oil pump.

Some engines have a thrust washer at upper end of bushing bore. Thrust washer, where used, may be replaced at same time bushing is replaced.

Lower bushing ordinarily will require only a clearance or wear check during engine overhaul. When distributor shaft-to-bushing clearance exceeds .0035" (.089mm), replace bushing, as follows, with oil pump and distributor removed:

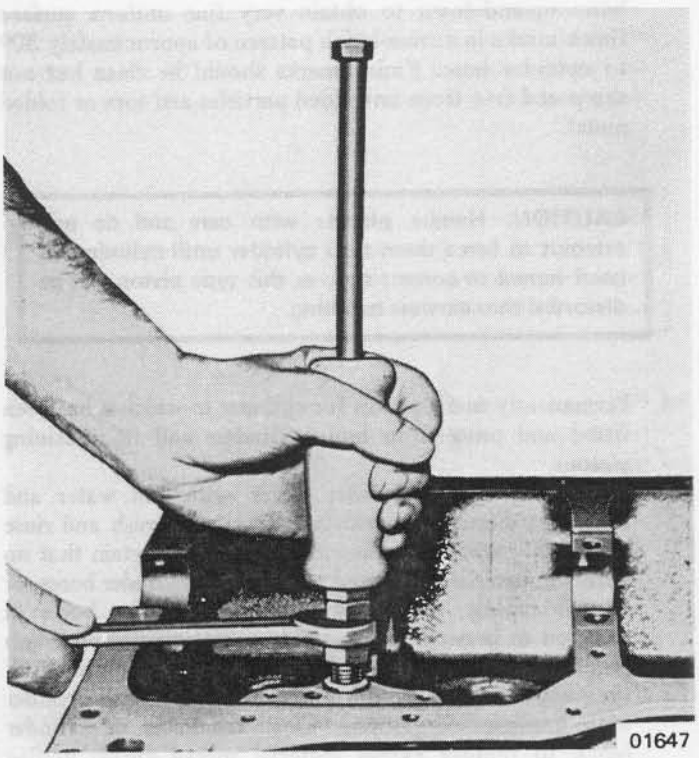


Figure 3. Removing Distributor Lower Bearing

NOTE: Later distributors use a bushing in distributor housing. Measuring clearance between cylinder block bushing and distributor shaft is not needed, since shaft is undercut.

1. Install Tool J-9534 into bushing and remove bushing with a slide hammer. (Figure 3)
2. Clean bushing bore in block and check for burrs or damage.

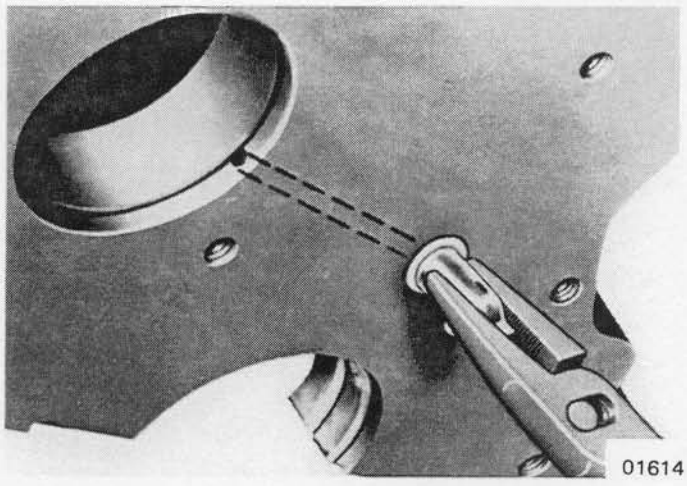
Figure 4. Install Distributor Lower Bearing

3. Use Tool J-9535 with driver-bolt in driver handle to install driver into new bushing from large inside diameter.
4. Position bushing and driver to block and drive bushing in position (Figure 4), which is determined by tool bottoming against block.

5. Remove tool from bushing. It is possible that bushing with minimum inside diameter will collapse enough during installation to slightly seize installer arbor. If this happens, remove installer tool with slide hammer in driver bolt hole of driver handle.

NOTE: This will not damage bushing, and tool is designed for this purpose, should it occur.

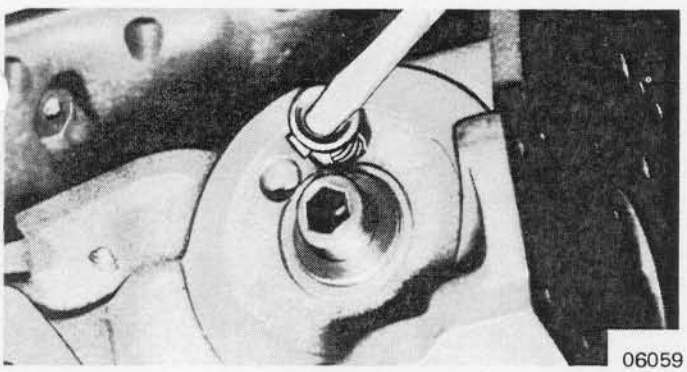
OIL NOZZLE REPLACEMENT



1. Remove nozzle with pliers. (Figure 5)
2. Drive new nozzle in place (oil hole in vertical position) with a suitable light plastic or rubber hammer.

Figure 5. Oil Nozzle Replacement

OIL FILTER BYPASS VALVE and REPLACEMENT



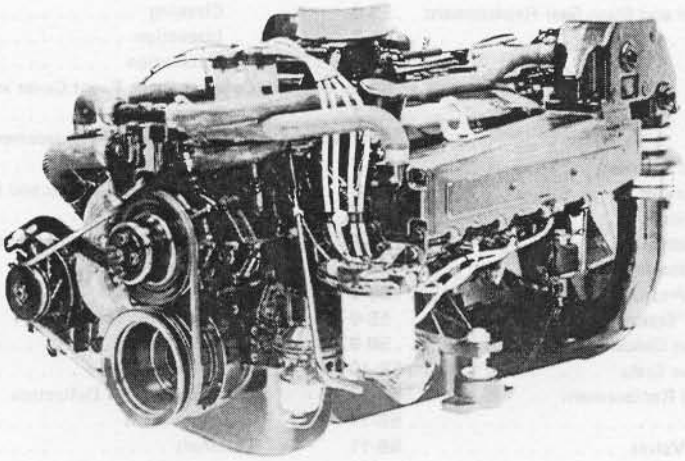
With oil filter removed, check spring and fibre valve for operation. Inspect for a cracked or broken valve. If replacement is necessary, pry valve out with screwdriver. Install and seat a new valve by tapping in place with a 9/16 thin-wall deep socket. (Figure 6)

Figure 6. Oil Filter By-Pass Valve

SECTION 5 - ENGINE

MERCRUISER

PART B - ENGINE MECHANICAL, V-8 FORD



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MERCURY MARINE

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ENGINE MECHANICAL

V-8 (302 and 351 Cu. In.) FORD ENGINE

TOOLS

*** All "J" Prefix (Special) Tools Listed Herein May Be Purchased from:**

Kent-Moore, Inc.
28635 Mound Road
Warren, Michigan 48089

*** All "T" Prefix (Special) Tools Herein May Be Purchased from:**

Owatonna Tools, Inc.
Attn: Ford Order Desk
Owatonna, Minnesota 55060

* *If ordering tool number(s) shown in discussion on following pages, number(s) may be superseded by newer tool(s) which will be sent by tool manufacturer listed above.*

GENERAL

Some repairs, which are listed in this section, must be completed with the engine removed from the boat. Type of repair and boat design determine if the engine is to be removed.

Place engine on an engine stand for major repairs.

Right hand and left hand rotation engines have similar repair procedures, as outlined in this section. Component crankshafts, camshafts, front and rear crankshaft seals and circulating water pumps, however, vary between right and left hand rotating engines.

INTAKE MANIFOLD

NOTE: Intake manifold and related parts are shown in Figure 1.

REMOVAL

1. Drain water from cylinder block.
2. Remove coil bracket bolt and move coil aside.
3. Remove temperature sender leads.
4. Remove distributor cap and move cap aside.
5. Remove 2 bolts which secure thermostat housing to intake manifold.

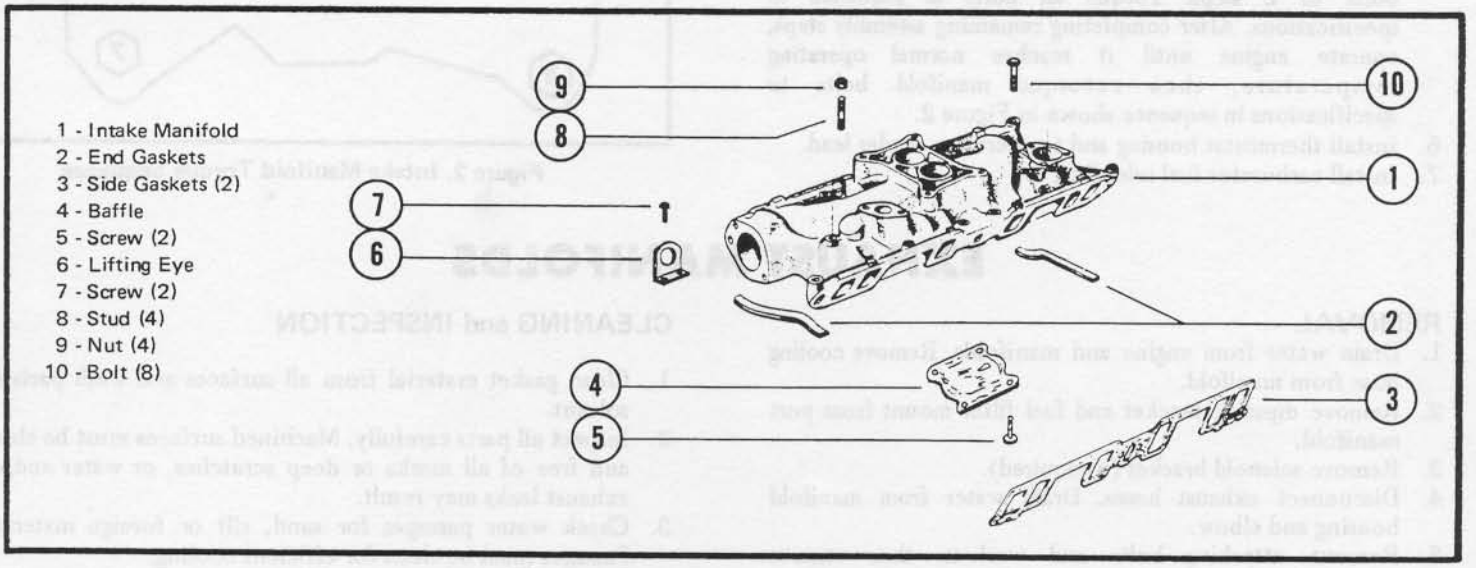


Figure 1. Intake Manifold and Related Parts

6. Remove carburetor fuel inlet line and throttle linkage.
7. Disconnect crankcase vent hose at rocker arm cover.
8. Remove manifold attaching bolts and nuts. Remove manifold and carburetor as an assembly. It may be necessary to pry intake manifold away from cylinder head(s). Use caution to avoid damage to gasket sealing surfaces.
9. Remove intake manifold gaskets and seals. Discard intake manifold attaching bolt sealing washers.

CLEANING

1. Remove all gasket material from machined surfaces of manifold.
2. Clean manifold in a suitable solvent and dry with compressed air.

INSPECTION

1. Inspect manifold for cracks, damaged gasket surfaces or other defects.
2. Replace studs which are stripped or damaged.
3. Remove all filings and foreign matter that may have entered manifold during repair.

INSTALLATION

1. If replacing manifold assembly, transfer engine lifting eye, temperature sending unit, carburetor and spacer. Install new gasket.
2. Clean mating surface of intake manifold, cylinder heads and cylinder block. Use a suitable solvent to remove all traces of oil. Coat cylinder block seal surfaces with Perfect Seal (C-92-34227).
3. Position new seals on cylinder block and new gaskets on cylinder heads with gaskets interlocked with seal tabs. Be sure that holes in gaskets are aligned with holes in cylinder heads.
4. Carefully lower intake manifold into position on cylinder block and cylinder heads. After intake manifold is in place, run a finger around the seal area to make sure that seals are in place.
5. Be certain that holes in manifold gaskets and manifold are in alignment. Using new sealing washers, install intake manifold attaching bolts and nuts. Torque intake manifold bolts in 2 steps. Torque all bolts in sequence to specifications. After completing remaining assembly steps, operate engine until it reaches normal operating temperature, then retorque manifold bolts to specifications in sequence shown in Figure 2.
6. Install thermostat housing and temperature sender lead.
7. Install carburetor fuel inlet line.
8. Connect crankcase vent hose. Install coil.
9. Connect throttle linkage.
10. Install distributor cap.
11. Operate engine at fast idle and check all hose connection and gaskets for leaks. When engine temperatures hav stabilized, adjust engine idle speed and idle fuel mixture.

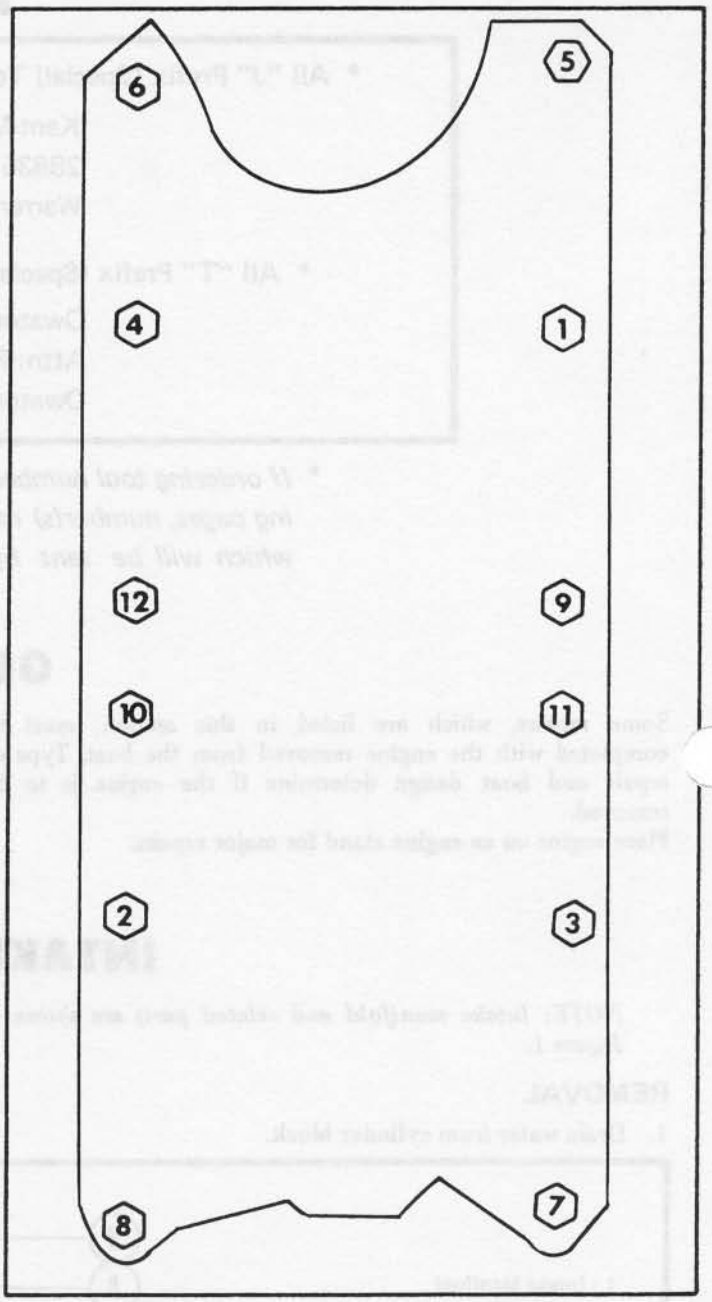


Figure 2. Intake Manifold Torque Sequence

EXHAUST MANIFOLDS

REMOVAL

1. Drain water from engine and manifolds. Remove cooling hose from manifold.
2. Remove dipstick bracket and fuel filter mount from port manifold.
3. Remove solenoid bracket (if required).
4. Disconnect exhaust hoses. Drain water from manifold housing and elbow.
5. Remove attaching bolts and washers, then remove manifold.

CLEANING and INSPECTION

1. Clean gasket material from all surfaces and wash parts in solvent.
2. Inspect all parts carefully. Machined surfaces must be clean and free of all marks or deep scratches, or water and/or exhaust leaks may result.
3. Check water passages for sand, silt or foreign material. Passages must be clean for efficient cooling.
4. Pipe plugs may be removed from exhaust manifold elbow

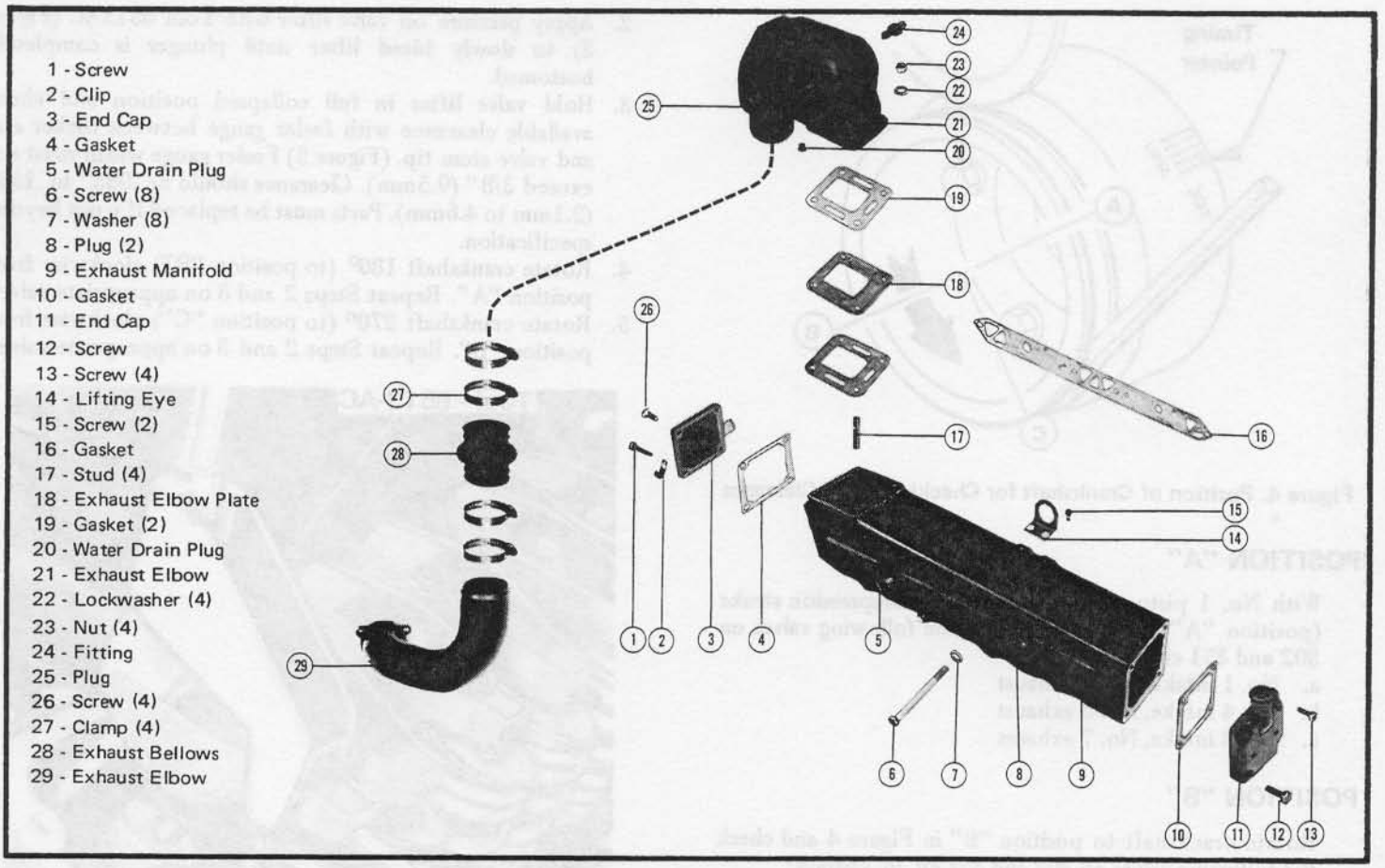


Figure 3. Exhaust Manifold (Starboard) and Related Parts

and exhaust pipe elbow, if more thorough inspection is desired.

INSTALLATION

1. Clean mating surfaces of exhaust manifold and cylinder head.
2. Position exhaust manifold on cylinder head with new gaskets and install attaching bolts and washers. Torque bolts to specifications from center to ends.
3. Install exhaust hoses and drain plugs.
4. Install dipstick housing bracket and fuel filter on port manifold.
5. Install solenoid bracket (if required).
6. Install cooling inlet hose.
7. Start engine and check for leaks.

ROCKER ARM COVER

REMOVAL

1. Remove carburetor vent hose from starboard cover.
2. Remove attaching bolts and remove rocker arm cover(s).

INSTALLATION

1. Clean gasket surfaces and position cover(s) in place with new gasket.
2. Install rocker cover bolts (with harness clamps on right manifold) and torque cover(s) to specifications shown in Section 8.
3. Install carburetor vent hose in rocker cover(s).

VALVE CLEARANCE

If a noise is present in valve train (which is not caused by a collapsed hydraulic lifter), use the following procedure to check for worn components in the valve train. If check indicates that clearance is not to specifications, replace worn parts in valve train to bring limit within specifications.

1. Position No. 1 piston at TDC (position "A") at end of compression stroke. Use chalk to mark points "B" and "C" approximately 90° apart. (Figure 4) Adjust only valves indicated for position "A".

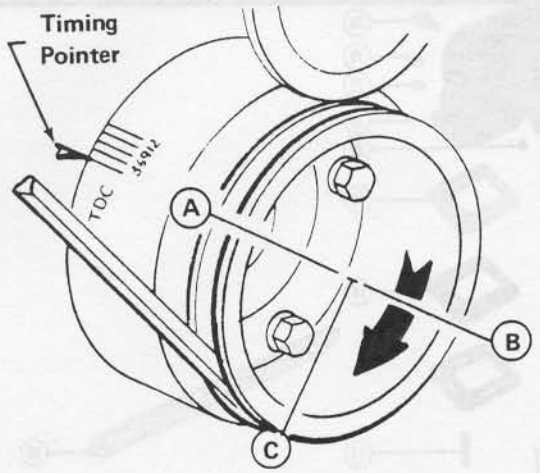


Figure 4. Position of Crankshaft for Checking Valve Clearance

POSITION "A"

With No. 1 piston on TDC at end of compression stroke (position "A" in Figure 4), check the following valves on 302 and 351 cu. in. engines:

a. No. 1 intake, No. 1 exhaust
b. No. 4 intake, No. 3 exhaust
c. No. 8 intake, No. 7 exhaust

POSITION "B"

Rotate crankshaft to position "B" in Figure 4 and check the following valves on 302 and 351 cu. in. engines:

a. No. 3 intake, No. 2 exhaust
b. No. 7 intake, No. 6 exhaust

POSITION "C"

Rotate crankshaft to position "C" in Figure 4 and check the following valves on 302 and 351 cu. in. engines:

a. No. 2 intake, No. 4 exhaust
b. No. 5 intake, No. 5 exhaust
c. No. 6 intake, No. 8 exhaust

2. Apply pressure on valve lifter with Tool 6513AC (Figure 5) to slowly bleed lifter until plunger is completely bottomed.
3. Hold valve lifter in full collapsed position and check available clearance with feeler gauge between rocker arn and valve stem tip. (Figure 5) Feeler gauge width must not exceed 3/8" (9.5mm). Clearance should be .083" to .183" (2.1mm to 4.6mm). Parts must be replaced if worn beyond specification.
4. Rotate crankshaft 180° (to position "B") clockwise from position "A". Repeat Steps 2 and 3 on appropriate valves.
5. Rotate crankshaft 270° (to position "C") clockwise from position "B". Repeat Steps 2 and 3 on appropriate valves.

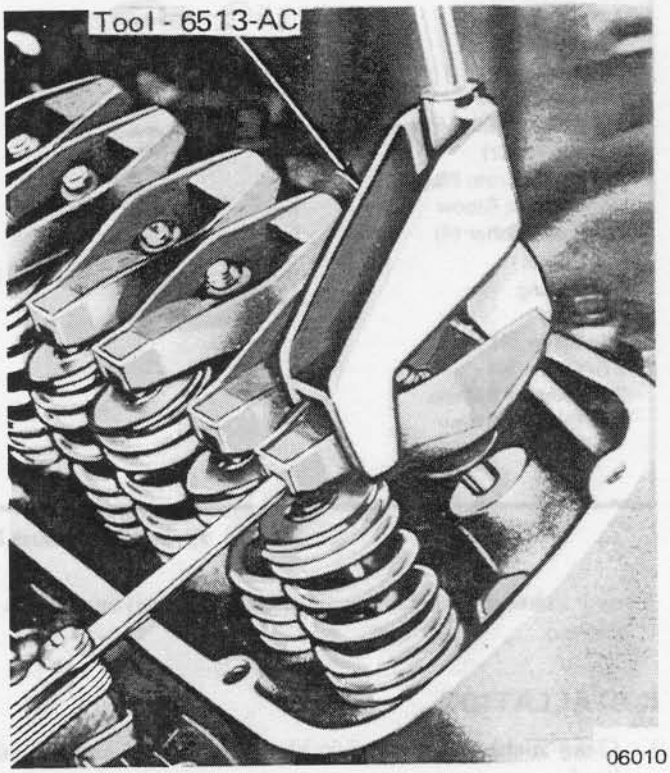


Figure 5. Checking Valve Clearance

VALVE MECHANISM

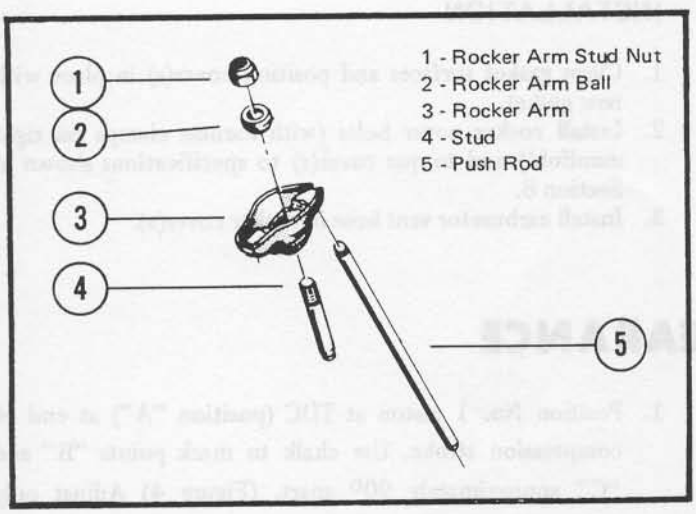


Figure 6. Valve Mechanism and Related Parts

NOTE: Valve mechanism is shown in Figure 6.

REMOVAL

1. Remove rocker arm cover(s) as outlined.
2. Remove rocker arm stud nut, ball unit and rocker arm.

NOTE: Keep all parts in order when removed (to reinstall in same location).

3. Remove push rod(s) and identify (to reinstall in same location).

CLEANING

Clean all parts thoroughly in solvent. Make sure that all oil passages are open. Be certain that oil passage in push rod end of rocker arm is open.

INSPECTION

Check rocker arm pad, side rails and ball seat for excessive wear, cracks, nicks or burrs. Check rocker arm stud and nut for stripped or broken threads. Check ends of push rods for nicks, grooves, roughness or excessive wear. Check push rods visually for straightness while they are installed in engine by rotating rods with valve closed. Push rods also can be checked with a dial indicator.

INSTALLATION

1. Apply engine oil to top of valve stem and ball units.
2. Install rocker arm, ball unit and stud nut.
3. Install rocker arm cover(s) as outlined, preceding.

HYDRAULIC VALVE LIFTERS

NOTE: Hydraulic lifters are shown in Figures 7 and 8.

Hydraulic valve lifters require little attention. Lifters are extremely simple in design, readjustments are not necessary and servicing requires only that care and cleanliness are exercised in the handling of parts.

LOCATING NOISY LIFTERS

Locate a noisy valve lifter by using a piece of garden hose approximately 4 ft. (1.2m) in length. Place one end of hose near end of each intake and exhaust valve, with other end of hose to the ear. In this manner, the sound is localized, making it easy to determine which lifter is at fault.

Another method is to place a finger on face of valve spring retainer. If lifter is not functioning properly, a distinct shock will be felt when valve returns to its seat.

General types of valve lifter noise are as follows:

1. Hard rapping noise -- Usually caused by plunger becoming tight in bore of lifter body so that return spring cannot push plunger back up to working position. Probable causes are:
   a. Excessive varnish or carbon deposit, causing abnormal stickiness.
   b. Galling or "pick-up" between plunger and bore of lifter body, usually caused by an abrasive piece of dirt or metal wedged between plunger and lifter body.
2. Moderate rapping noise -- Probable causes are:
   a. Excessively high leakdown rate.
   b. Leaky check valve seat.
   c. Improper adjustment.
3. General noise throughout valve train -- This will, in most cases, be a definite indication of insufficient oil supply or improper adjustment.
4. Intermittent clicking -- Probable causes are:
   a. A microscopic piece of dirt momentarily caught between ball seat and check valve ball.
   b. In rare cases, ball itself may be out-of-round or have a flat spot.
   c. Improper adjustment.

In most cases, where noise exists in one or more lifters, all lifter units should be removed, disassembled, cleaned in solvent, reassembled and reinstalled in engine. If dirt, corrosion, carbon, etc, is shown to exist in one unit, it more likely exists in all the units, thus it would only be a matter of time before all lifters caused trouble.

REMOVAL

1. Remove intake manifold as outlined.
2. Remove valve mechanism as outlined.
3. Remove valve lifters.

NOTE: Place valve lifters in a rack so that they may be reinstalled in the same location.

Internal parts of each hydraulic valve lifter assembly are matched sets. Do not intermix parts. Keep assemblies intact until cleaning. Disassembly and assembly procedures vary for Types I and II valve lifters. See Figures 7 and 8 for identification.

TYPE I DISASSEMBLY

Disassemble and assemble each lifter separately. Identify lifter assemblies so that they will be reinstalled in original bores.

1. Grasp lock ring with needle-nose pliers to release ring from groove. It may be necessary to depress plunger to fully release lock ring.
2. Remove push rod cup, metering valve (disc), plunger and spring.
3. Remove plunger assembly, check valve and check valve retainer and plunger spring. Carefully remove plunger spring, check valve retainer and check valve disc from plunger.

TYPE I REASSEMBLY (Figure 7)

1. Place plunger upside down.
2. Place check valve (disc or ball check) in position over oil hole on bottom of plunger. Set check valve spring on top of check valve (disc or ball check).
3. Position check valve retainer over check valve and spring and push retainer down into place on plunger.

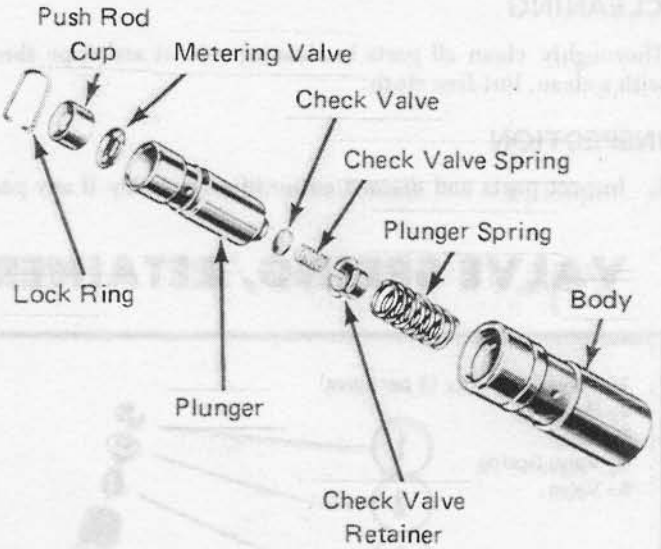


Figure 7. Type I Hydraulic Valve Lifter Assembly

4. Place plunger spring and plunger (open end up) into lifter body.
5. Position metering valve (disc) in plunger, then place push rod cup in plunger.
6. Depress plunger and position closed end of lock ring in groove of lifter body. With plunger still depressed, position

open ends of lock ring in groove. Release plunger, then depress it again to fully seat lock ring.

TYPE II DISASSEMBLY

Each valve lifter is a matched assembly. If parts of one lifter are intermixed with parts of another, improper valve operation may result. Disassemble and assemble each lifter separately. Keep lifter assemblies in proper sequence so that they will be reinstalled in original bores.

1. Grasp lock ring with needle-nose pliers to release ring from groove. It may be necessary to depress plunger to fully release lock ring.
2. Remove push rod cup, metering valve disc and upper metering valve. Do not bend metering valve or valve tensioning finger.
3. Remove plunger assembly, check valve and check valve retainer and plunger spring. Carefully remove plunger spring, check valve retainer and check valve disc from plunger.

TYPE II REASSEMBLY (Figure 8)

1. Place plunger in an inverted position and center check valve disc on plunger. Carefully slide check valve over disc and down until valve bottoms. A slight turning motion will help. Use every precaution not to distort valve in any way, nor to bend preformed fingers. With slight turning motion, slide plunger spring over metering valve and down until spring seats.
2. Leaving assembly inverted, slide lifter body down over spring until body slightly compresses spring.
3. Place combined assembly right-side-up on work surface.
4. Position upper metering valve in plunger, taking care not to tilt it to either side and not to damage or bend valve tensioning finger. Place metering valve disc over metering valve and install push rod cup. Depress cup and install lock ring.

CLEANING

Thoroughly clean all parts in cleaning solvent and wipe them with a clean, lint-free cloth.

INSPECTION

1. Inspect parts and discard entire lifter assembly if any part shows pitting, scoring, galling, excessive wear or evidence or non-rotation.
2. Replace entire assembly, if plunger is not free in body. Plunger should drop to bottom of body by its own weigh when assembled dry.
3. Assemble lifter assembly and check for freedom of operation by pressing down on push rod cup.

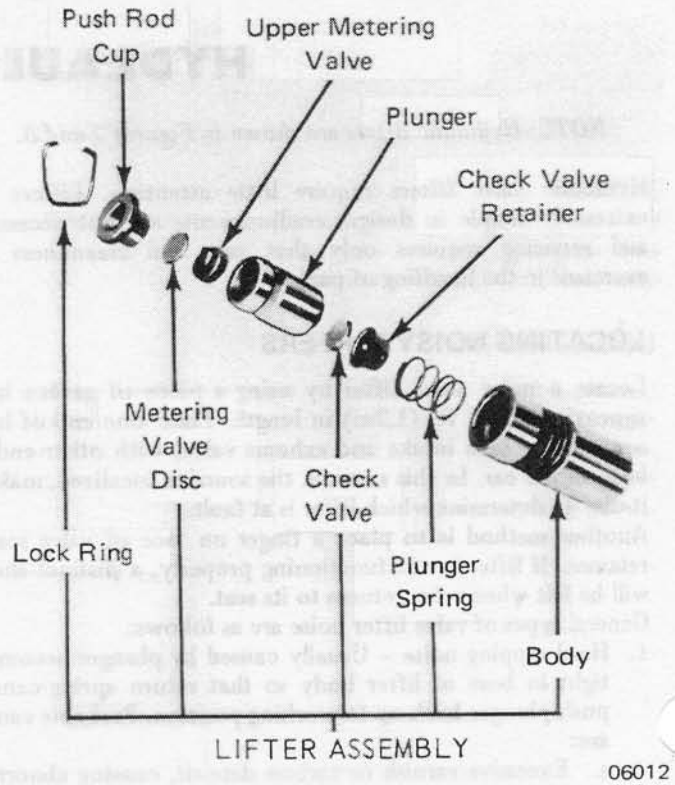


Figure 8. Type II Hydraulic Valve Lifter Assembly

INSTALLATION

1. Install valve lifters.

   NOTE: Whenever valve lifters are being installed, coat foot of valve lifters with engine oil.

2. Install intake manifold as outlined.
3. Install and adjust valve mechanism as outlined.

VALVE SPRING, RETAINER and STEM SEAL REPLACEMENT

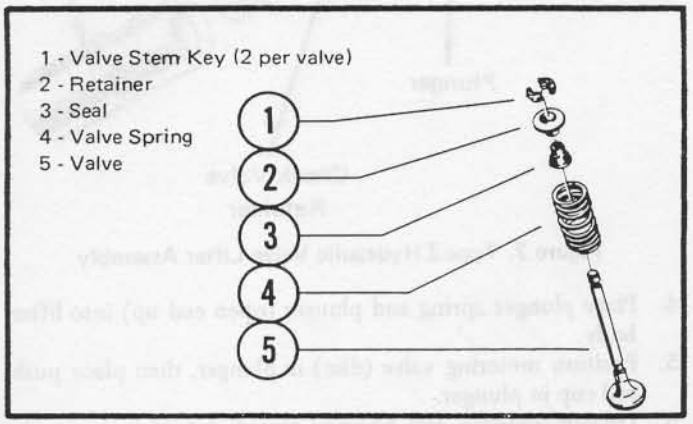


Figure 9. Valve and Related Parts

NOTE: Valve and related parts are shown in Figure 9.

Broken valve springs or damaged valve stem seals and retainers may be replaced without removing cylinder head if no damage to valve or valve seat.

1. Remove valve rocker arm cover and spark plug of cylinder that valve spring will be removed.
2. Remove valve rocker arm stud nuts, ball units, valve rocker arms and push rods from applicable cylinder.
3. Install an air line with adaptor in spark plug hole and turn on air.
4. Install stud nut and position compressor tool as shown in Figure 11. Compress valve spring and remove retainer locks, spring retainer and valve spring.
5. Remove and discard valve stem seal.

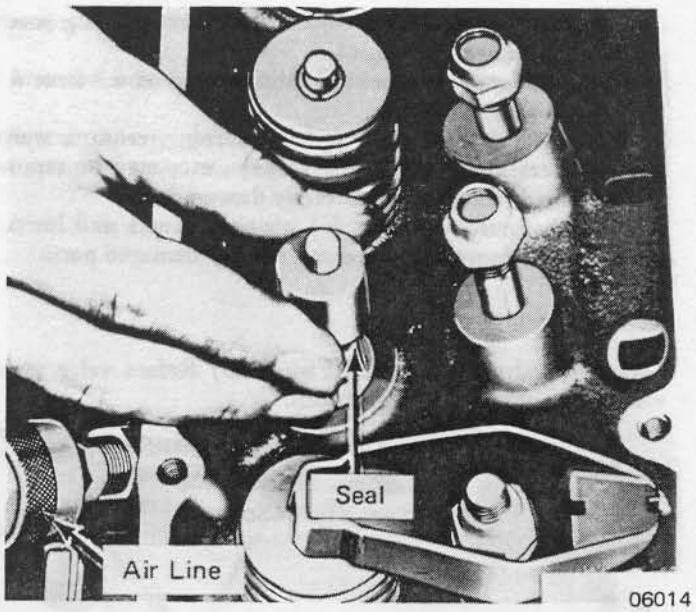


Figure 10. Compressing Valve Spring

6. If air pressure has forced piston to bottom of cylinder, any removal of air pressure will allow valve(s) to fall into cylinder. A rubber band, tape or string (wrapped around end of valve stem) will prevent valve(s) from dropping and still allow enough travel to check the valve for binds.
   Move valve up and down thru normal travel in valve guide and check stem for binds. If valve has been damaged, remove cylinder head for repairs as outlined, following.
7. Inspect valve stem for damage. Rotate valve and check valve stem tip for eccentric movement during rotation.
8. If condition of valve is satisfactory, hold valve in closed position and apply air pressure to cylinder.
9. Install a new valve stem seal. (Figure 10) Place spring in position over valve and install valve spring retainer. Compress valve spring and install valve spring retainer locks. (Figure 11) Remove compressor tool and stud nut.
10. Install valve mechanism as outlined.
11. Remove air line and adaptor. Install spark plug and wire.
12. Install rocker arm cover as outlined.

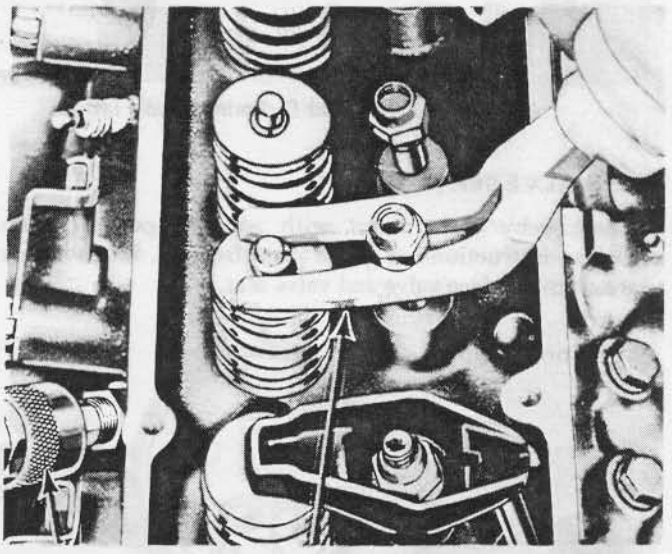


Figure 11. Removing or Installing Valve Stem Seal

CYLINDER HEAD

If replacing a cylinder head, follow procedures under "Cylinder Head Disassembly and Assembly", following, and transfer all valves, springs, spark plugs, etc, to new cylinder head. Clean and inspect all parts, reface valves and check all assembly clearances before assembling new or used parts to new cylinder head.

REMOVAL

1. Remove intake manifold as outlined.
2. Remove exhaust manifold(s) as outlined.
3. Remove rocker arm cover(s) as outlined.
4. Loosen distributor cap and remove spark plug wire hold-down. Remove plug wires and distributor cap as an assembly.
5. Remove spark plugs.
6. Remove valve mechanism as outlined.
7. Remove cylinder head attaching bolts and lift cylinder head off block.

DISASSEMBLY

1. Clean carbon out of cylinder head combustion chambers before removing valves.
2. Compress valve springs. (Figure 11) Remove spring retainer locks and release spring.
3. Remove spring retainer, spring, stem seal and valve. Discard valve stem seals. Identify all valve parts (to reinstall in same location).
4. Clean, inspect and repair cylinder head, as required, or transfer all usable parts to a new cylinder head.

CLEANING

1. With valves installed to protect valve seats, remove deposits from combustion chambers and valve heads with a scraper and wire brush. Be careful not to damage cylinder head gasket surface.
2. After removing valves, clean valve guide bores with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits.
3. Clean all bolt holes and remove all deposits from valves with a fine brush or buffing wheel.

INSPECTION

Check cylinder head for cracks and inspect gasket surface for burrs and nicks. Replace head if cracked.

CYLINDER HEAD FLATNESS

When a cylinder head is removed because of gasket leaks, check cylinder head for flat gasket surface according to specifications. (Figure 12) If necessary to refinish cylinder head gasket surface, do not plane or grind off more than .010" (.25mm).

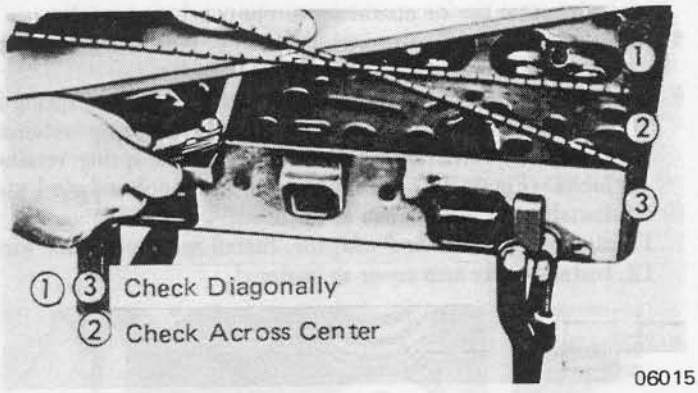


Figure 12. Typical Cylinder Head Flatness

VALVE SEAT RUNOUT

Check valve seat runout with accurate gauge. (Figure 13) Follow instructions of gauge manufacturer. If runout exceeds wear limit, reface valve and valve seat.

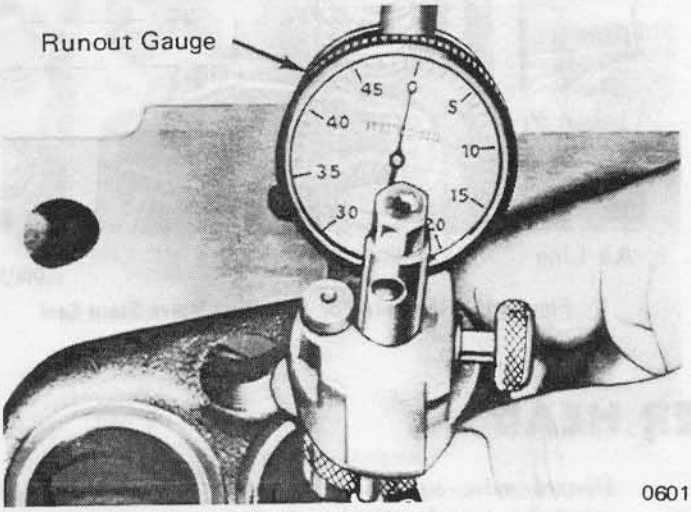


Figure 13. Checking Valve Seat Runout

VALVE INSPECTION

1. The critical inspection points and tolerances of valves are illustrated in Figure 14. Refer to specifications for wear limits.

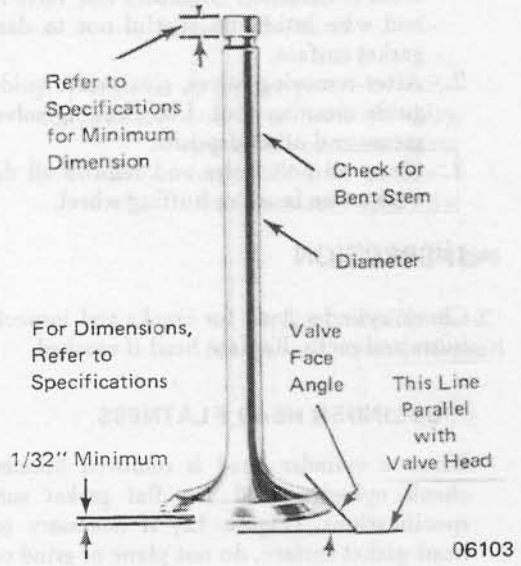


Figure 14. Critical Valve Dimensions

2. Inspect valve face and edge of valve head for pits, grooves, scores or other damage.
3. Inspect stem for bent condition and end of stem for grooves or scores.
4. Check valve head for signs of burning, erosion, warpi and cracking. Minor pits, grooves, etc, may be removed. Discard valves that are severely damaged.
5. Inspect valve spring, valve spring retainers and locks for wear or damage. Discard any visually damaged parts.

VALVE SEAT WIDTH

Measure valve seat width. (Figure 15) Reface valve seats if width is not within specifications.

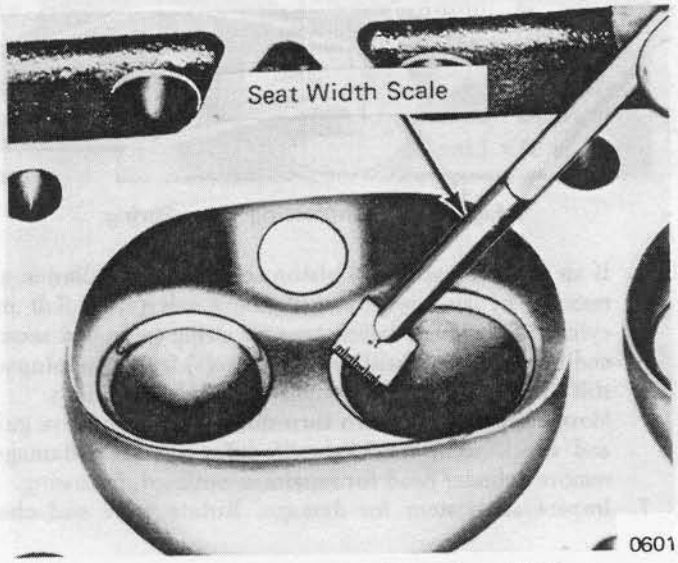


Figure 15. Checking Valve Seat Width

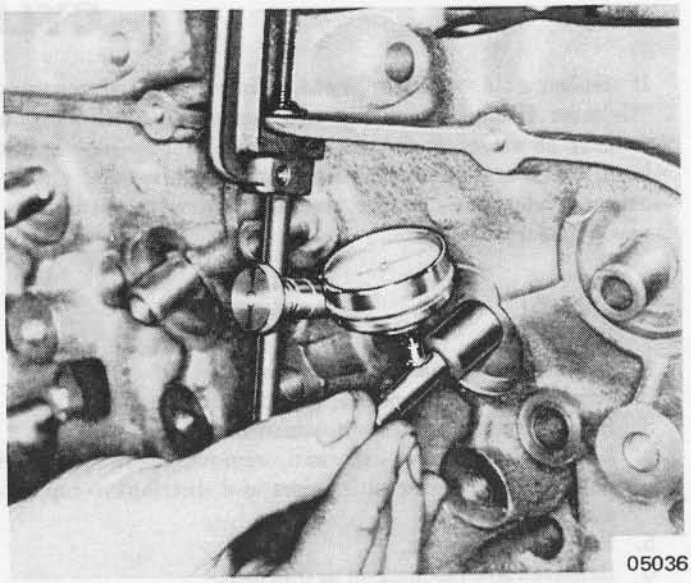


Figure 16. Checking Valve Stem Clearance

VALVE STEM CLEARANCE

1. Measure valve stem clearance (Figure 16) as follows: Clamp a dial indicator on one side of cylinder head rock arm cover gasket rail, locating indicator so that movement of valve stem from side to side (crosswise to the head) will cause a direct movement of indicator stem. Indicator stem must contact side of valve stem just above valve guide.
2. With valve head dropped about 1/16" (1.6mm) off valve

seat, move valve stem from side-to-side, using light pressure to obtain a clearance reading.

3. If clearance exceeds specifications, it will be necessary to ream valve guides for oversize valves, as outlined.

VALVE SPRING PRESSURE

1. Check springs for correct pressure at specified spring lengths with Tool J-8056. (Figure 17)

   IMPORTANT: DO NOT manually rotate valve spring assemblies while installed in engine to determine good and/or bad valve springs. Weak valve springs cause poor engine performance.

2. Replace any spring not within specifications.

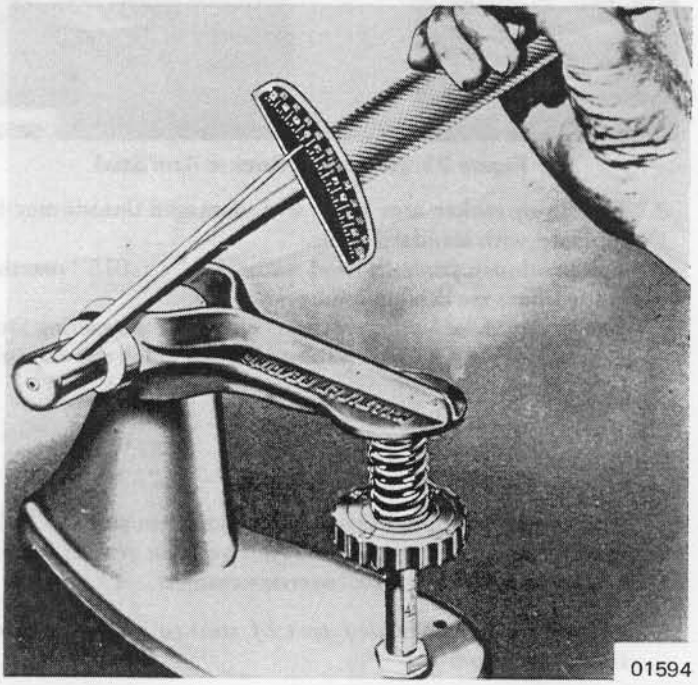


Figure 17. Checking Valve Spring Pressure

VALVE SPRING "SQUARE"

1. Check each spring for "square" with a steel square and flat surface. (Figure 18)
2. Stand spring and square on end on flat surface. Slide spring up to square.
3. Revolve spring slowly and observe space between top coil of spring and square. Out-of-square limits are 5/16" (8mm).
4. Follow same procedure to check new valve springs before installation.

   IMPORTANT: Make certain that proper spring (color coded) is installed.

5. Visually inspect valve spring retainer to determine if damper spring coil has been hitting retainer. This interference also will cause a clicking noise when engine is operating. Damper spring is properly installed in valve spring when positioned so that end of damper spring bottom coil is 135° counterclockwise from end of valve spring lower coil.

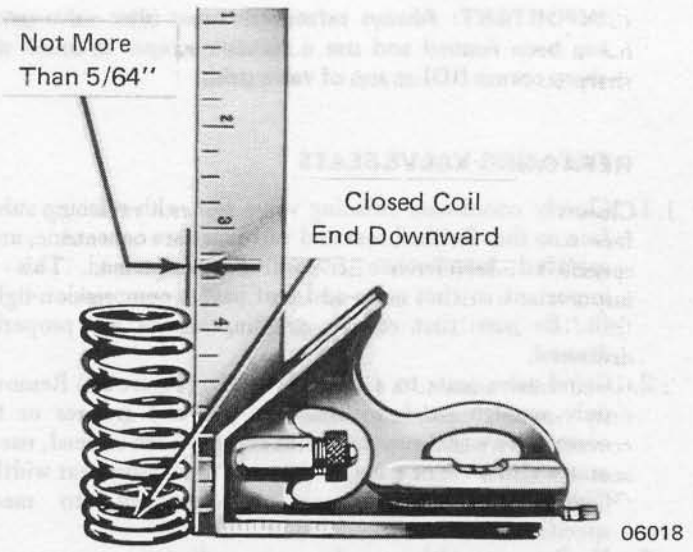


Figure 18. Checking Valve Spring Squareness

REAMING VALVE GUIDES

1. If valve stem to valve guide clearance exceeds the wear limit, ream valve guide for next oversize valve stem (.015" [.38mm] available).
2. Use Reaming Kit T526-6085-AEE when reaming a valve guide (Figure 19) to install valve with oversize stem. Kit has .003" (.075mm) OS reamer with standard diameter pilot and .015" OS reamer with .003" OS pilot.
3. When going from standard size valve to oversize valve, always use .063" oversize reamer before using .015" oversize finish-reamer.

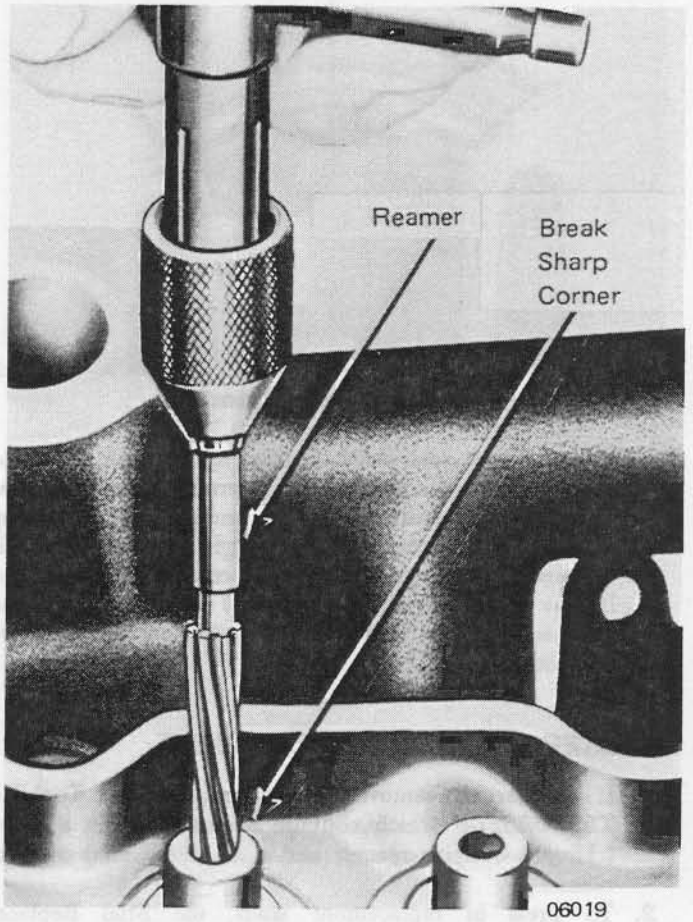


Figure 19. Reaming Valve Guides

IMPORTANT: Always reface valve seat after valve guide has been reamed and use a suitable scraper to break the sharp corner (ID) at top of valve guide.

REFACING VALVE SEATS

1. Closely coordinate refacing valve seat with refacing valve face so that finished seat and valve face are concentric, and specified interference fit will be maintained. This is important so that valve and seat have a compression-tight fit. Be sure that refacer grinding wheels are properly dressed.
2. Grind valve seats to a true 45° angle. (Figure 20) Remove only enough stock to clean up pits and grooves or to correct valve seat runout. After seat has been refaced, use a seat width scale or a machinist scale to measure seat width. (Figure 20) Narrow seat, if necessary, to meet specifications.
3. If valve seat width exceeds maximum limit, remove enough stock from top edge and/or bottom edge of seat to reduce width to specifications.
4. On valve seats of all engines, use a 60° angle grinding wheel to remove stock from bottom of seats (raise seats) and use a 30° angle wheel to remove stock from top of seats (lower seats).

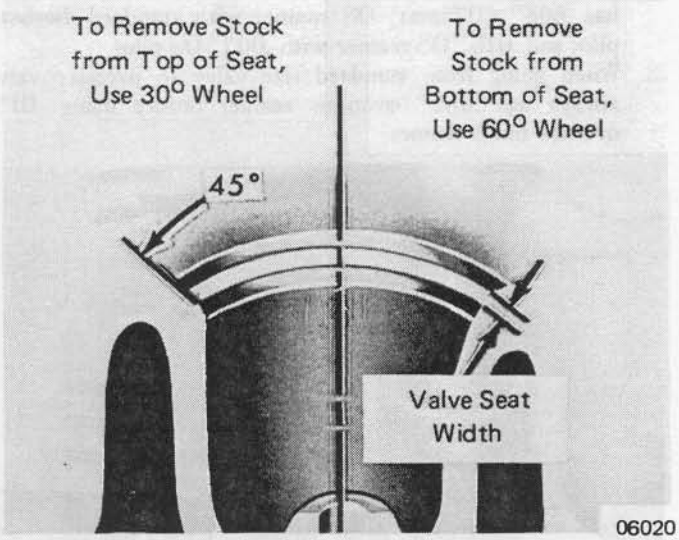


Figure 20. Refacing Valve Seat

5. Finished valve seat should contact approximate center of valve face. It is good practice to determine where valve seat contacts face by coating seat with Prussian blue and setting valve in place. Rotate valve with light pressure. If blue is transferred to center of valve face, contact is satisfactory. If blue is transferred to top edge of valve face, lower the valve seat. If blue is transferred to bottom edge of valve face, raise valve seat.

ROCKER ARM STUD REPLACEMENT

1. If necessary to remove a rocker arm stud, use Tool Kit T62F-6A527-B which contains a stud remover, a .006" (.15mm) oversize reamer and a .015" (.38mm) oversize reamer.
2. To press in replacement studs, use Stud Replacer T69P-6049-D.

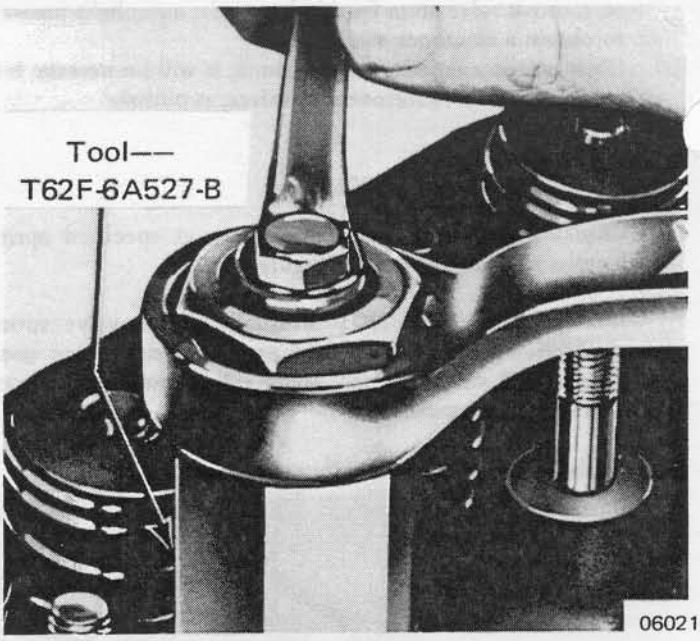


Figure 21. Removing Rocker Arm Stud

3. Broken or rocker arm studs with damaged threads may be replaced with standard studs.
4. Replace loose studs in head with .006" or .015" oversize studs which are available for service.
5. Identify standard and oversize studs by measuring stud diameter within 1-1/8" (28.6mm) from pilot end of stud. Stud diameters are:

   Standard : .3714" - .3721"
   .006" Oversize: .3774" - .7781"
   .015" Oversize: .3864" - .3871"

6. When going from standard-size rocker arm stud to .015" oversize stud, always use .006" oversize reamer before finish-reaming with .015" oversize reamer.

   NOTE: Cut off threaded part of stud to permit remover tool installation.

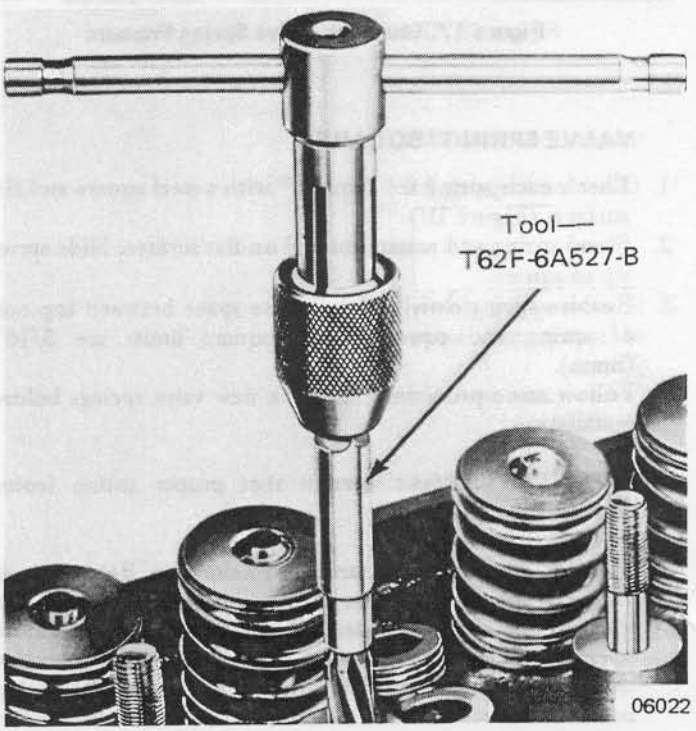


Figure 22. Reaming Rocker Arm Stud Bore

a. Position sleeve of rocker arm stud Remover Tool T62F-6A527-B over stud with bearing end down. Thread puller into sleeve and over stud until fully bottomed. Hold puller with wrench, then rotate sleeve clockwise to remove stud. (Figure 21) If rocker arm stud was broken off flush with stud boss, use an easy-out to remove broken stud, following instructions of tool manufacturer.
b. If replacing a loose rocker arm stud, ream stud bore with correct reamer (or reamers in sequence) for selected oversize stud. (Figure 22)

IMPORTANT: Make certain that metal particles DO NOT ENTER valve area.

c. Use Tool T69P-6049-D when installing stud. (Figure 23)

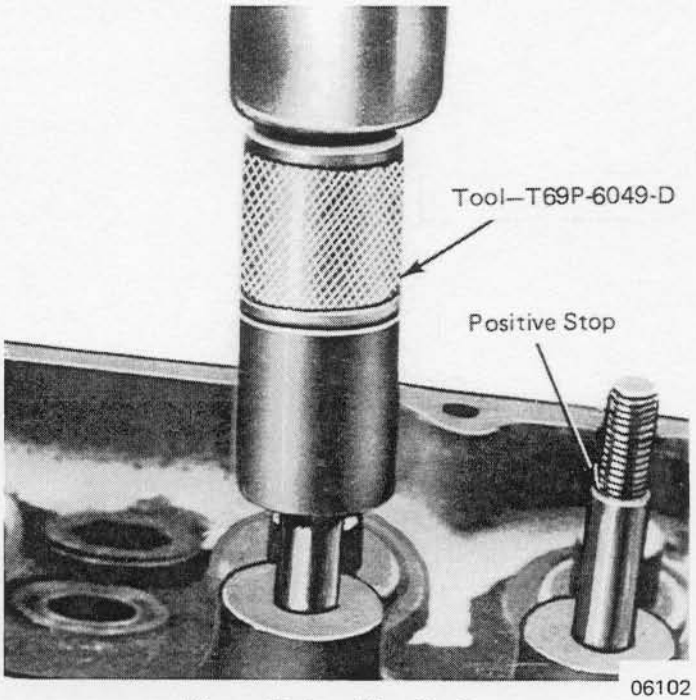


Figure 23. Installing Stud

VALVES

1. Minor pits, grooves, etc, may be removed. Discard severely damaged valves, or if face runout or stem clearance exceeds specifications.
2. Discard any worn or damaged valve train parts.

REFACING VALVES

1. Closely coordinate valve refacing operation with valve seat refacing operations so that finished angles of valve face and of valve seat will meet specifications and provide a compression-tight fit. Be sure that refacer grinding wheels are properly dressed.
2. If valve face runout is excessive and/or to remove pits and grooves, reface valves to a true 44° angle. Remove only enough stock to correct runout or to clean up pits and grooves. If edge of valve head is less than 1/32" (.8mm) thick after grinding, replace valve, as valve will run too hot in engine. Interference fit of valve and seat should not be lapped out.
3. Remove all grooves or score marks from end of valve stem and chamfer it as necessary. Do not remove more than .010" (.25mm) from end of the valve stem. Valve stem from valve lock groove to end (Figure 14, preceding) must not be shorter than minimum specified length.
4. If valve and/or valve seat has been refaced, it will be necessary to check clearance between rocker arm seat and valve stem with valve train assembly installed in engine.

REASSEMBLY

1. Install each valve in port from which it was removed or to which it was fitted. Install a new stem seal on valve.
2. Install valve spring over the valve, then install spring retainer. Compress spring and install retainer locks. (Figure 24)

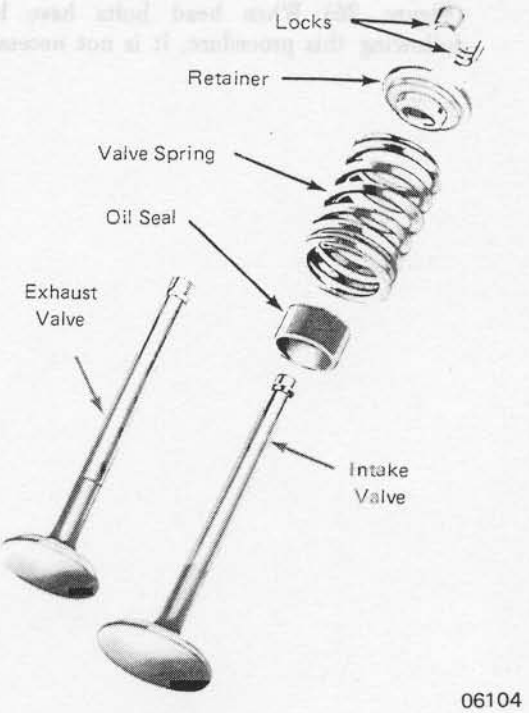


Figure 24. Valve Assembly

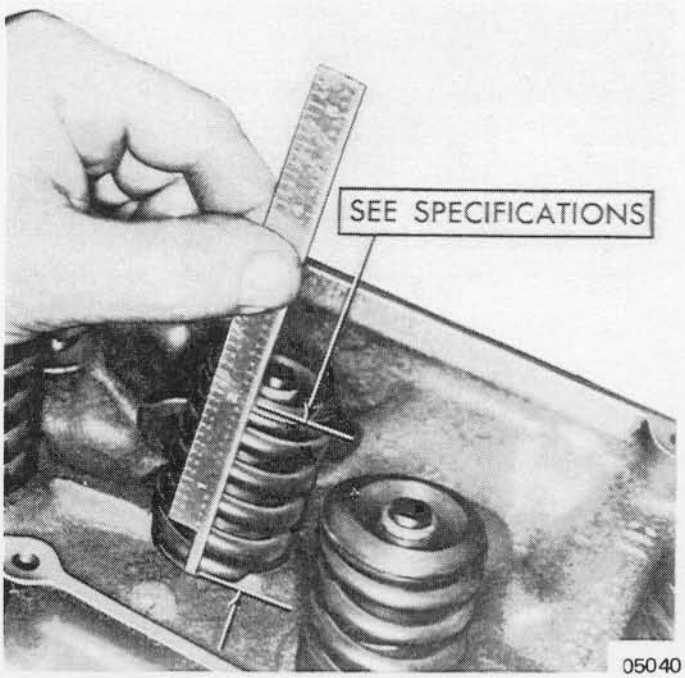


Figure 25. Measuring Spring Height

3. Measure assembled height of valve spring from surface of cylinder head spring seat to underside of spring retainer with dividers. (Figure 25) Check dividers against a scale. If assembled height is greater than or less than specifications, replace valve spring.

INSTALLATION

1. Clean all gasket surfaces to obtain flat, smooth cylinder head and block mating.
2. Position new cylinder head gasket over cylinder head dowels on block. Position cylinder head on block and install attaching bolts.
3. Cylinder head bolts are tightened in 3 progressive steps. Torque all bolts in sequence and finally to specifications. (Figure 26) When head bolts have been tightened, following this procedure, it is not necessary to retorque bolts after extended operation. Bolts may be checked, however, and retorqued, if desired.
4. Install valve mechanism as outlined, preceding.
5. Install rocker arm cover(s) as described previously.
6. Install intake manifold as outlined, preceding.
7. Install exhaust manifolds as described previously.

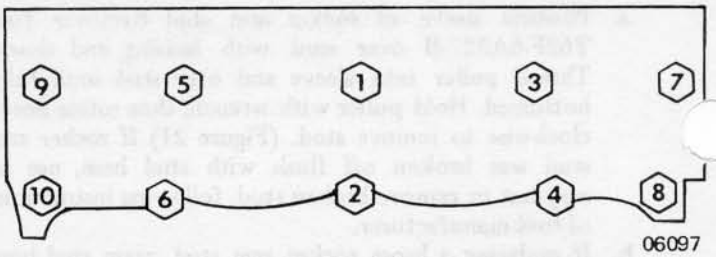


Figure 26. Cylinder Head Bolt Torque Sequence

OIL PAN

REMOVAL

1. Drain crankcase. Remove oil level dipstick and tube.
2. Remove seawater pump adjustment bracket.
3. Remove attaching screws and washers and remove oil pan.

CLEANING

1. Scrape any dirt or metal particles from inside of pan.
2. Scrape all old gasket material from gasket surface.
3. Wash pan in solvent and dry thoroughly. Be sure that all foreign particles are removed from below baffle plate.

INSPECTION

1. Check pan for cracks, holes, damaged drain plug threads and loose baffle or damaged gasket surface.
2. Inspect for damage (uneven surface caused by overtorquing bolts) at bolt holes. Straighten surfaces as required.
3. Repair any damage or replace pan if repairs cannot be made.

INSTALLATION

1. Before installing aluminum oil pan, coat surfaces of front and rear oil pan gasket (rubber) (Figure 1) with Silicone Sealant (C-92-52238-1).
2. Clean gasket surfaces of block and oil pan. Oil pan has a 2-piece gasket. Coat block surface and oil pan gasket with Perfect Seal (C-92-34227). Position oil pan gaskets on cylinder block.
3. Position oil pan front seal on cylinder block front cover.
4. Position oil pan rear seal on rear main bearing cap. (Figure 1) Be sure that tabs on seals are over oil pan gasket.
5. Install oil pan bolts, torquing to specifications from center outward in each direction.
6. Install oil level dipstick tube and dipstick. Fill crankcase with correct grade and quantity of engine oil. Start engine and check for oil leaks.

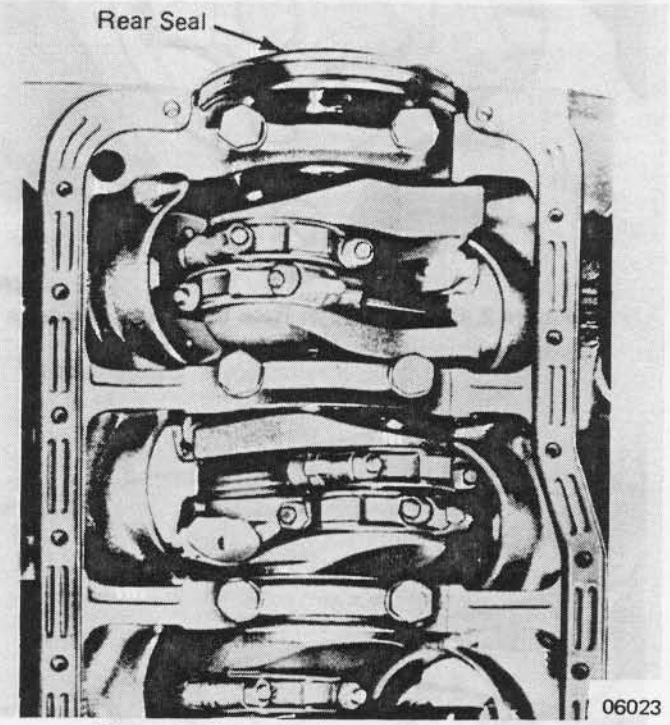


Figure 1. Oil Pan Gaskets and Seals Installed

OIL PUMP

NOTE: Oil pump assembly is shown in Figure 4.

REMOVAL

1. Remove oil pan as outlined, preceding.
2. Remove oil pump attaching bolts and remove oil pump, gasket and intermediate drive shaft.

DISASSEMBLY

1. Remove oil inlet tube from oil pump and remove gasket.
2. Remove cover attaching screws and cover. Remove inner rotor and shaft assembly, then remove outer race.
3. Insert a self-threading sheet metal screw of proper diameter into oil pressure relief valve chamber cap and pull cap out of chamber. Remove spring and plunger.

CLEANING

1. Wash all parts in a solvent and dry them thoroughly with compressed air.
2. Clean inside of pump housing and pressure relief valve chamber with a brush. Be sure that all dirt and metal particles are removed.

INSPECTION

1. Check inside of pump housing and outer race and rotor for damage or excessive wear.
2. Replace cover if cover mating surface is worn, scored or grooved.
3. Measure outer race to housing clearance (min. .006" [.15mm] to max. .013" [.33mm]). (Figure 2)
4. With rotor assembly installed in housing, place a straight edge over rotor assembly and housing. Measure clearance (rotor end play) between straight edge and rotor and outer race (min. .0011" [.028mm] to max. .0041" [.104mm]). (Figure 3)

   NOTE: Outer race, shaft and rotor are replaceable as an assembly.

5. Check drive shaft to housing bearing clearance by measuring OD of shaft and ID of housing bearing (min. .0015" to max. .0029").
6. Inspect relief valve spring for collapsed or worn condition. If worn or damaged replace spring.
7. Check relief valve piston for scores and free operation in bore.

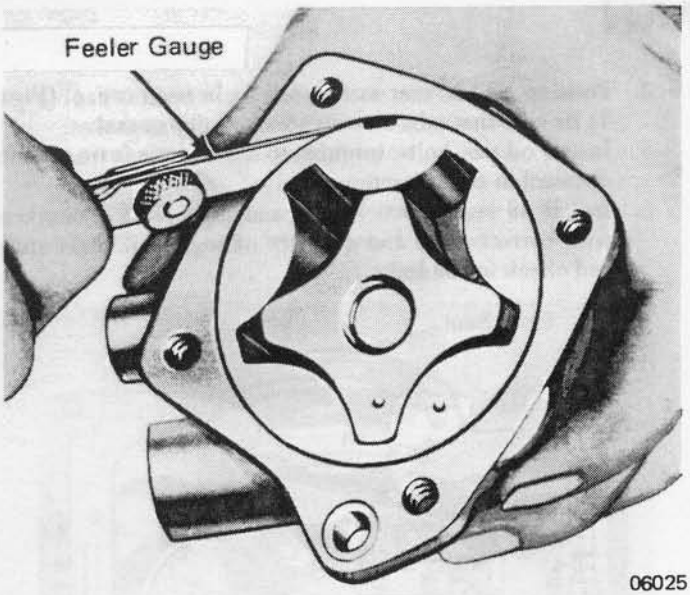


Figure 2. Checking Outer Race to Housing Clearance

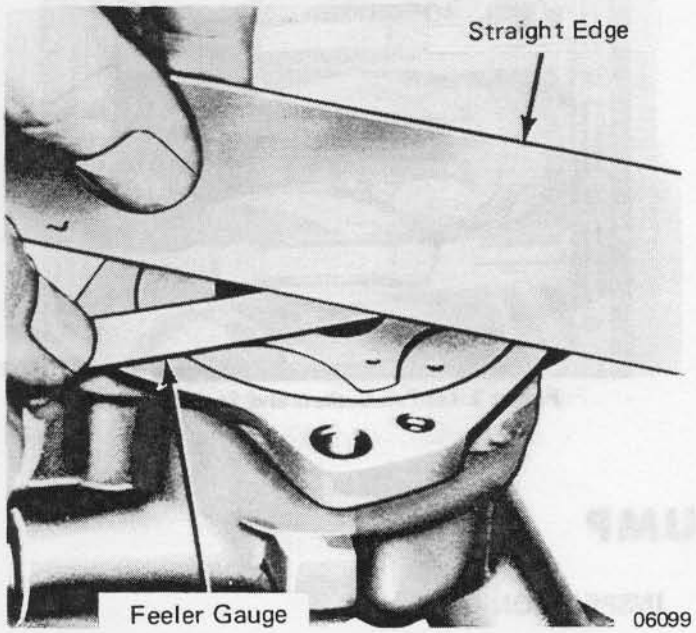


Figure 3. Checking Rotor End Play

REASSEMBLY

Oil pump assembly is shown in Figure 4.

1. Oil all parts thoroughly.
2. Install oil pressure relief valve plunger, spring and new cap.
3. Install outer race and inner rotor and shaft assembly. Be sure that dot (identification mark) on outer race is facing outward and on same side as identification mark on rotor. (Figure 2) The race rotor and shaft and outer race are serviced as an assembly. Do not replace one part without replacing other.
4. Install cover and torque cover attaching screws to 9 to 12 ft. lbs. (1.24 to 1.66mkg).
5. Position new gasket and oil inlet tube on oil pump and install attaching bolts. Torque to 12-15 ft. lbs. (1.66 to 2.07mkg).

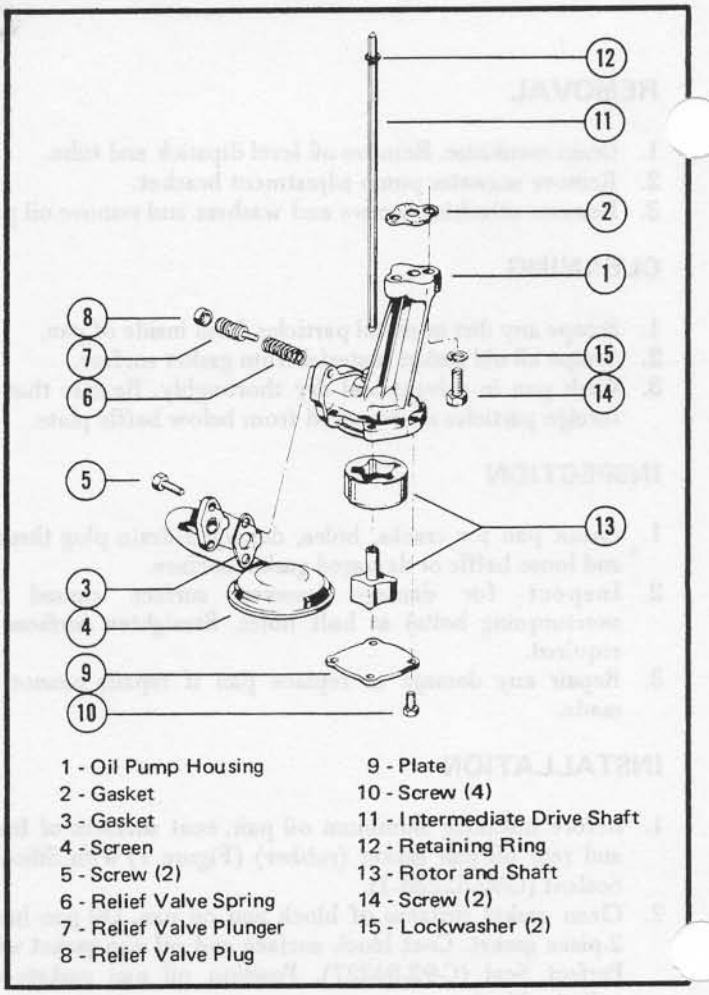


Figure 4. Oil Pump Assembly

INSTALLATION

1. Prime oil pump by filling either inlet or outlet port with engine oil. Rotate pump shaft to distribute oil within pump body.
2. Position intermediate drive shaft into distributor socket. With shaft firmly seated in distributor socket, stop on shaft should touch roof of crankcase. Remove shaft and position stop as necessary.
3. Position new gasket on pump housing. With stop properly positioned, insert intermediate drive shaft into oil pump. Install pump and shaft as an assembly.

IMPORTANT: Do not attempt to force pump into position if it will not seat readily. Drive shaft hex may be misaligned with distributor shaft. To align, rotate intermediate drive shaft into a new position.

4. Torque oil pump attaching screws to 23 to 28 ft. lbs. (3.18 to 3.87mkg).
5. Install oil pan and related parts as outlined under "Oil Pa Installation", preceding.

FLYWHEEL

REMOVAL

1. Remove all attaching parts from flywheel housing.
2. Remove transmission (if so equipped).
3. Remove flywheel cover and housing.
4. Remove drive plate or engine coupling from flywheel.
5. Remove flywheel attaching bolts and remove flywheel.

INSPECTION

1. Inspect flywheel for cracks or other damage that may make it unfit for further service.
2. Inspect ring gear for worn, chipped or cracked teeth. If teeth are damaged, replace flywheel.

INSTALLATION

1. Position flywheel on crankshaft flange. Install and torque bolts in sequence across from each other.
2. Install drive plate or engine coupling.
3. Install flywheel housing and cover.
4. Install all parts which were removed from flywheel housing.
5. Install transmission (if so equipped).

PISTON ASSEMBLY

NOTE: Piston and related parts are shown in Figure 3.

REMOVAL

1. Drain water from cooling system and oil from crankcase. Remove intake and exhaust manifolds, cylinder heads, oil pan and oil pump as outlined.
2. Remove any ridges and/or deposits from upper end of cylinder bores as follows:
   a. Turn crankshaft until piston (to be removed) is at bottom of its travel and place a cloth on piston head to collect cuttings.
   b. Remove any ridge and/or deposits from upper end of cylinder bores.
   c. Remove cylinder ridge with a ridge cutter. Follow instructions furnished by tool manufacturers. Never cut into ring travel area in excess of 1/32" (.8mm) when removing ridges.
3. Make sure that all connecting rod caps are marked to be reinstalled in original positions.
4. Turn crankshaft until connecting rod and piston assembly (being removed) is at bottom of stroke.
5. Remove connecting rod nuts and cap.
6. Push connecting rod and piston assembly out top of cylinder with handle end of a hammer. Avoid damage to crankshaft journal or cylinder wall when removing piston and rod.
7. Install cap on connecting rod from which it was removed.

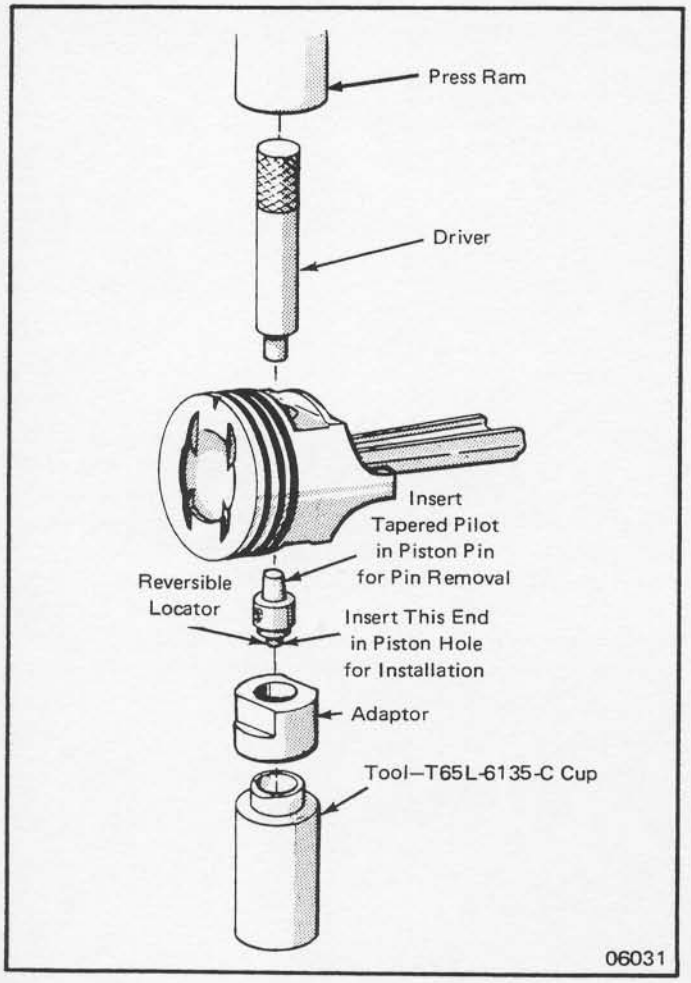


Figure 1. Removing or Installing Piston Pin

DISASSEMBLY

1. Remove bearing inserts from connecting rod end cap.
2. Mark pistons and pins to assure reassembly on same rod and installation in same cylinders from which they were removed.
3. Remove piston rings.
4. Use an arbor press and tool (shown in Figure 1) and press piston pin from piston and connecting rod.

CLEANING

Remove deposits from piston surfaces. Clean gum or varnish from piston skirt, piston pins and rings with solvent. DO NOT use a caustic cleaning solution or a wire brush to clean pistons. Clean ring grooves with ring groove cleaner. (Figure 2) Make sure that oil ring slots (or holes) are clean.

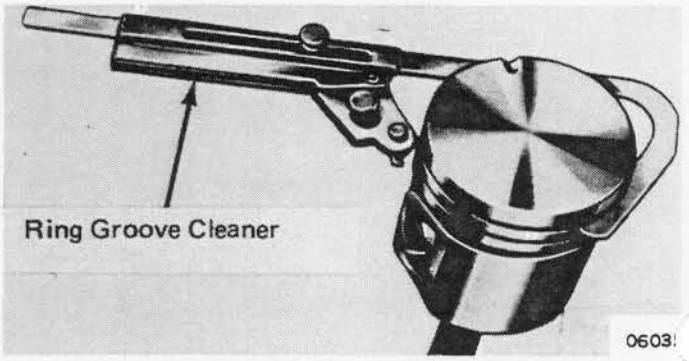


Figure 2. Cleaning Piston Ring Grooves -- Typical

INSPECTION

1. Carefully inspect pistons for fractures at ring lands, skirts and pin bosses and for scuffed, rough or scored skirts. If lower inner portion of ring grooves has a high step, replace piston. The step will interfere with ring operation and cause excessive ring side clearance.
2. Spongy, eroded areas near edge of top of piston usually are caused by detonation or pre-ignition. A shiny surface on thrust surface of piston, offset from centerline between piston pin holes, may be caused by a bent connecting rod. Replace pistons which show signs of excessive wear, wavy ring lands or fractures or damage from detonation or pre-ignition.
3. Check piston to cylinder bore clearance by measuring piston and bore diameters. Refer to specifications for proper clearance. Refer to "Cylinder Block Inspection" preceding, for bore measurement procedure. Measure OD of piston with micrometers at centerline of piston pin bore and at 90° to pin bore axis. Check ring side clearance following procedure under "Fitting Piston Rings" (see "Index").
4. If wear is present in piston pin area, replace piston.
5. Replace all rings which are scored, chipped or cracked. Check end gap and side clearance. DO NOT transfer rings from one piston to another.

REASSEMBLY

Piston, connecting rod and related parts are shown in Figure 3.

IMPORTANT: Check fit of a new piston in cylinder bore before assembling piston to connecting rod.

Piston pin bore of a connecting rod and diameter of piston pin must be within specifications.

1. Assemble piston to connecting rod with cylinder number side of connecting rod and notch in piston positioned as shown in Figure 4. On replacement connecting rods, install large-chamfered side of connecting rod bearing bore toward crankshaft cheek, facing toward front of engine on right bank rods and facing toward rear of engine of left bank rods.

   NOTE: DO NOT oil piston pin, piston or connecting rod before rod end is to be heated for installation. Parts must be clean and dry.

2. Heat piston pin end of connecting rod.

   NOTE: An oven is recommended to heat piston pin end of connecting rod prior to piston installation. (Figure 5)

3. Start piston pin in piston and connecting rod (this may require a very light tap with a mallet). Using an arbor press, press piston pin thru piston and connecting rod until pin is centered in piston. (Figure 1)
4. Allow connecting rod and piston assembly to cool, then oil piston pin.

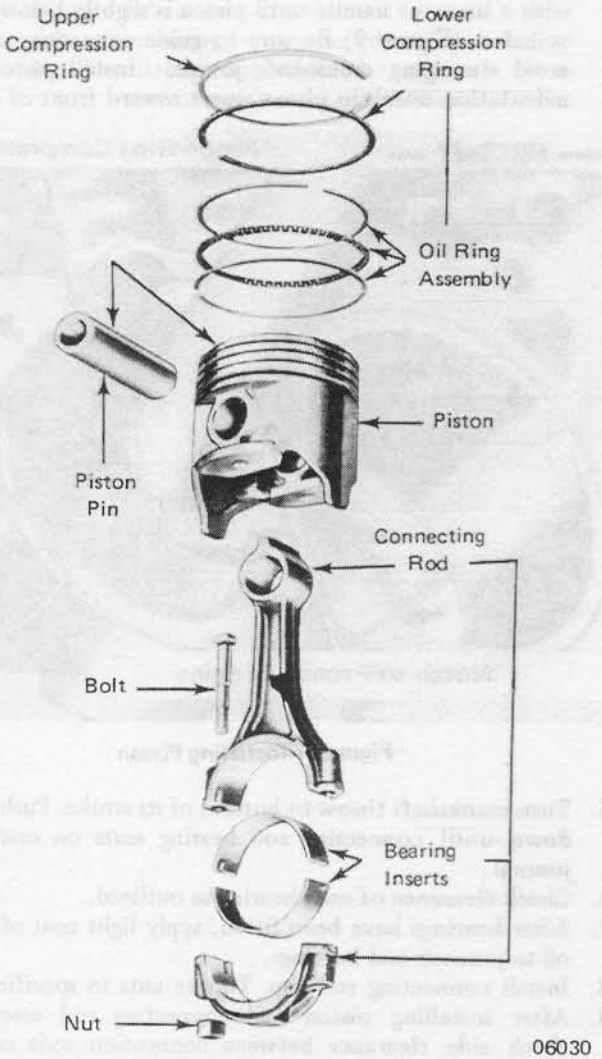


Figure 3. Piston, Connecting Rod and Related Parts

5. Install piston rings.
6. Be sure that bearing inserts and bearing bore in connecting rod and cap are clean. Foreign material under inserts will distort bearing and cause a failure. Install bearing inserts in connecting rod and cap with tangs fitting in slots provided.

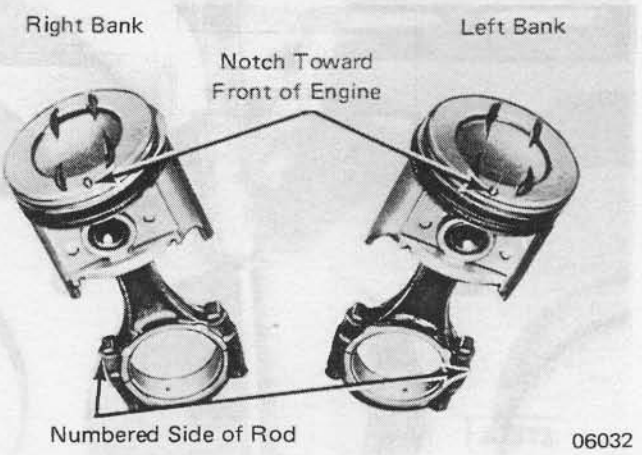


Figure 4. Correct Piston and Rod Positions

Figure 5. Heating Connecting Rod

FITTING PISTON RINGS

1. Select proper ring set for size of cylinder bore.
2. Position ring in cylinder bore in which it is to be used.
3. Push ring down into bore area where normal ring wear is not encountered.
4. Use head of a piston to position ring in bore so that ring is square with cylinder wall. Use caution to avoid damage to ring or cylinder bore.
5. Measure gap between ends of ring with a feeler gauge. (Figure 6) If ring gap is less or greater than specified limits, try another ring set.
6. Check ring side clearance of compression rings with a feeler gauge inserted between ring and its lower land.

(Figure 7) Gauge should slide freely around entire ring circumference without binding. Wear forms a step at inner portion of lower land. If lower lands have high steps, replace piston.

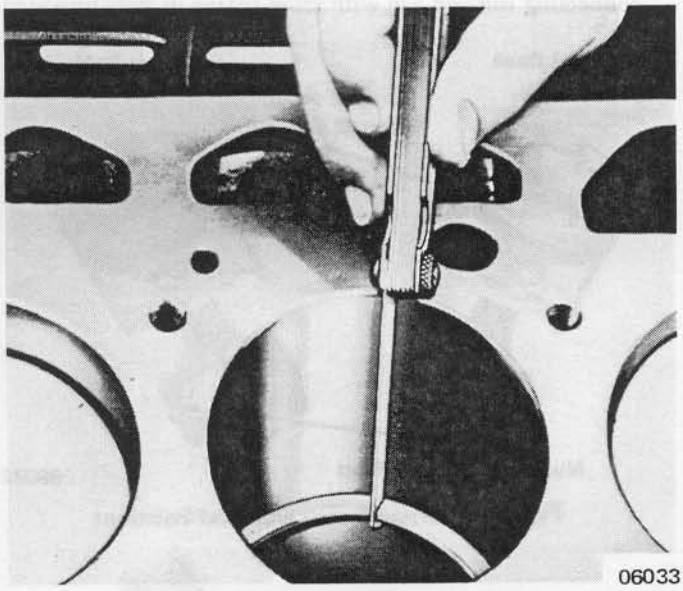


Figure 6. Checking Piston Ring Gap

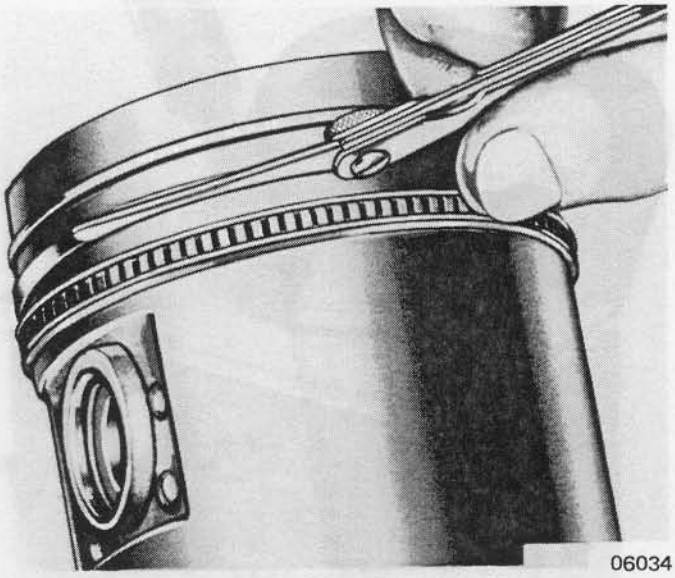


Figure 7. Checking Piston Ring Side Clearance

INSTALLATION

1. If installing new piston rings, remove cylinder wall glaze. Follow instructions of tool manufacturer.
2. Oil piston rings, pistons and cylinder walls with light engine oil.

IMPORTANT: Be sure to install pistons in same cylinders from which they were removed or to which they were fitted. Connecting rod and bearing caps are numbered from 1-to-4 in right bank and from 5-to-8 in left bank, beginning at front of engine. Numbers on connecting rod and bearing cap must be on same side when installed in cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, fit new bearings and number connecting rod to correspond with new cylinder number.

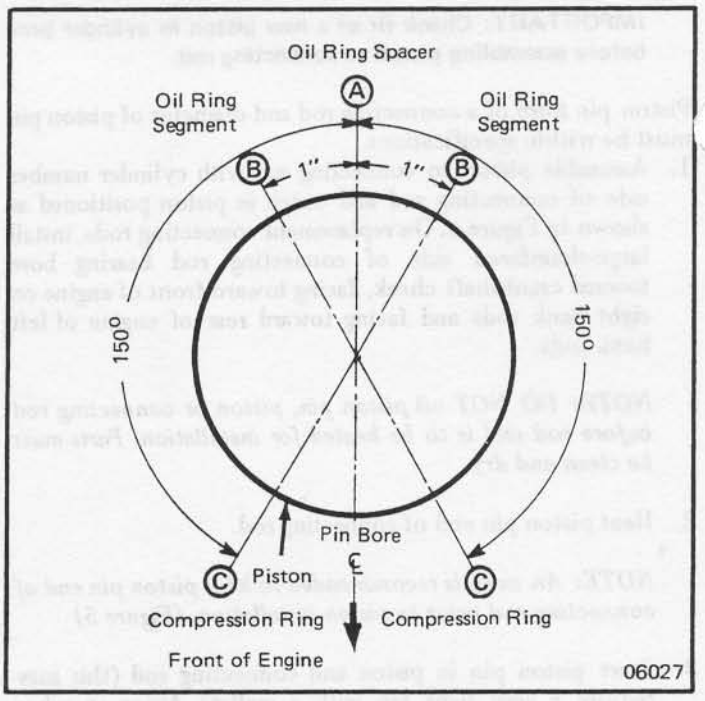


Figure 8. Piston Ring Spacing

3. Make sure that ring gaps are properly spaced around circumference of piston. (Figure 8)
4. Install piston ring compressor on piston and push piston in with a hammer handle until piston is slightly below top of cylinder. (Figure 9) Be sure to guide connecting rods to avoid damaging crankshaft journals. Install piston with indentation notch in piston dome toward front of engine.

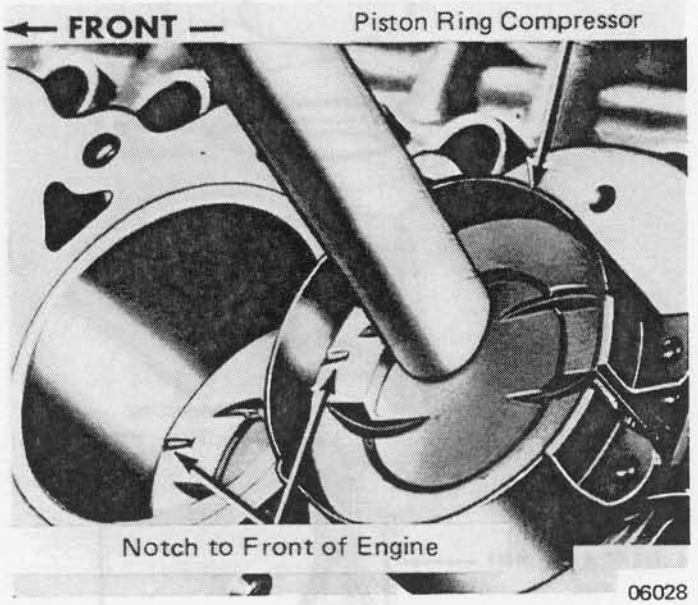
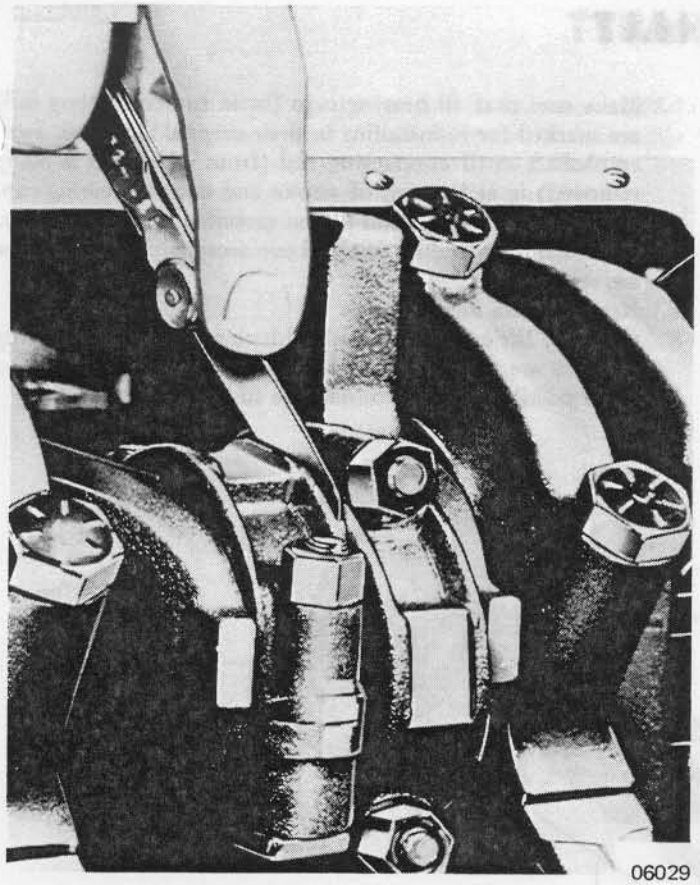


Figure 9. Installing Piston

5. Turn crankshaft throw to bottom of its stroke. Push piston down until connecting rod bearing seats on crankshaft journal.
6. Check clearance of each bearing as outlined.
7. After bearings have been fitted, apply light coat of engine oil to journals and bearings.
8. Install connecting rod cap. Torque nuts to specifications.
9. After installing piston and connecting rod assemblies, check side clearance between connection rods on each crankshaft journal. (Figure 10)



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10. Disassemble, clean and assemble oil pump. Clean all gasket surfaces.
11. Prime oil pump by filling either inlet port or outlet port with engine oil and rotating pump shaft to distribute oil within housing. Install oil pump and oil pan.
12. Install cylinder heads, intake and exhaust manifolds.
13. Fill crankcase with correct engine oil.
14. Operate engine at fast idle and check for oil and coolant leaks. When engine temperature has stabilized, adjust engine idle speed and idle fuel mixture.

Figure 10. Checking Connecting Rod Side Clearance

CONNECTING RODS

REMOVAL and DISASSEMBLY

Refer to "Piston Assembly, Removal - Disassembly" (see "Index").

CLEANING

Remove bearings from rod and cap. Identify bearings if re-using. Clean connecting rod in solvent, including rod bore and back of inserts. DO NOT use a caustic cleaning solution. Blow dry with compressed air.

INSPECTION

Carefully inspect connecting rods and related parts to meet specifications. Various forms of engine wear, related to these parts, can be readily identified.

1. Shiny surface on pin boss side of piston usually indicates a bent connecting rod, or piston pin hole is not in proper relation to piston skirt and ring grooves.
2. Abnormal connecting rod bearing wear may be caused by either a bent connecting rod, an improperly machined crankpin or a tapered connecting rod bore.
3. Twisted connecting rods will not create a wear pattern easy to identify, but badly twisted rods will disturb action of entire piston, rings and connecting rod assembly and may cause excessive oil consumption.
4. Inspect connecting rods for signs of fractures and bearing bores for out-of-round and taper. If bore exceeds recommended limits and/or, if connecting rod is fractured, replace rod.
5. If wear is present in piston pin hole, replace connecting rod.
6. Replace defective connecting rod nuts and bolts.
7. Check connecting rods for bend or twist on a suitable alignment fixture. Follow instructions of fixture manufacturer. If bend and/or twist exceeds specifications, replace connecting rod.

REASSEMBLY and INSTALLATION

Refer to "Piston Assembly, Reassembly - Installation" (see "Index").

CRANKSHAFT

Crankshaft and related parts are shown in Figure 1.

REMOVAL

1. Remove flywheel and mount engine on an engine stand. Turn engine to an inverted position.
2. Remove oil pan and oil pump as outlined, preceding.
3. Remove cylinder block front cover as described previously.
4. Remove spark plugs to allow easy rotation of crankshaft.
5. Remove timing chain and sprockets as outlined.
6. Make sure that all bearing caps (main and connecting rod) are marked for re-installing in their original locations. Turn crankshaft until connecting rod (from which cap is being removed) is at bottom of stroke and remove bearing cap. Push connecting rod and piston assembly up into cylinder. Repeat this procedure until all connecting rod bearing caps are removed.
7. Remove main bearing caps.
8. Carefully lift crankshaft out of block so that thrust bearing surfaces are not damaged. Handle crankshaft with care to avoid possible fracture or damage to finished surfaces.

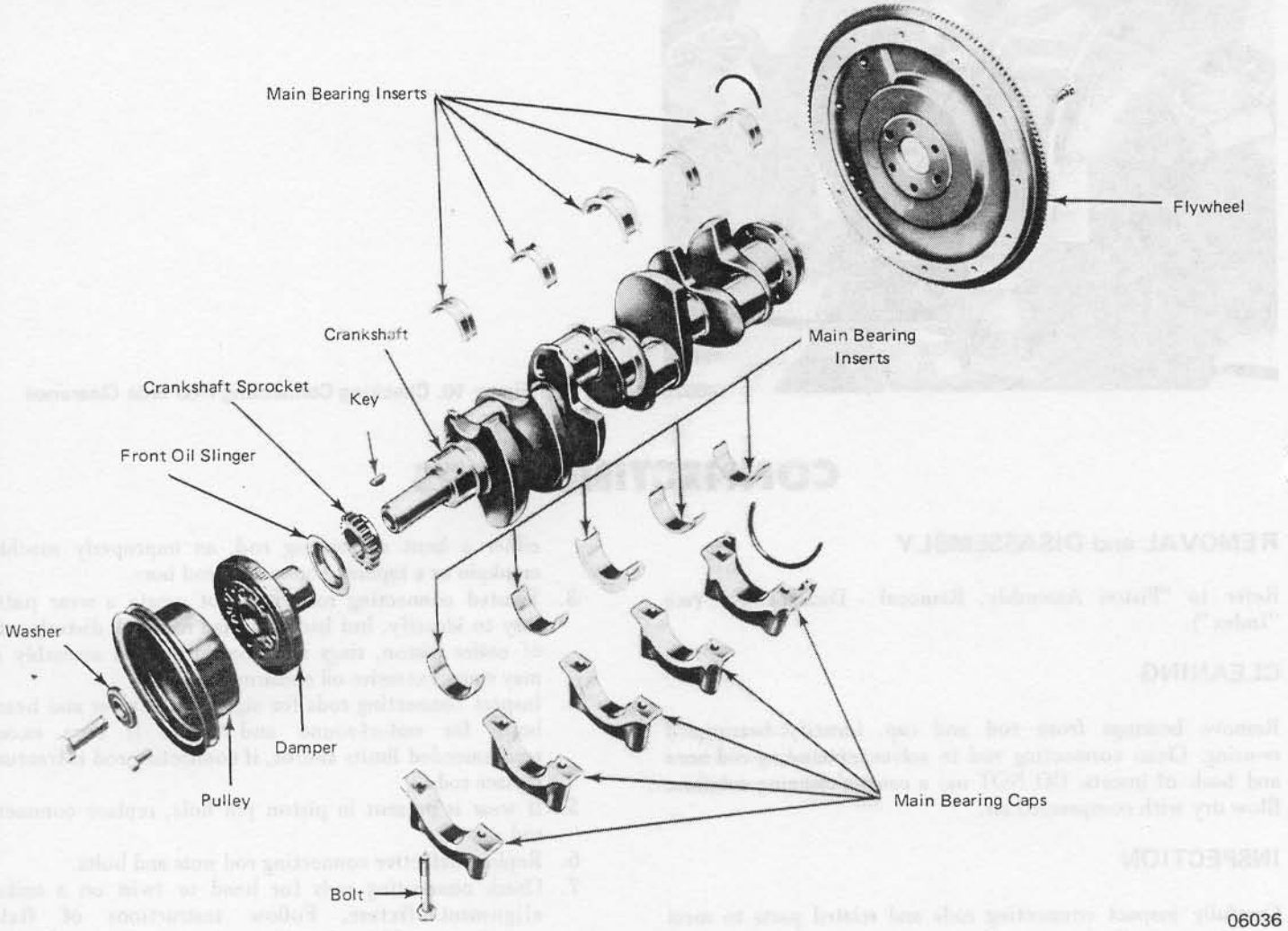

Figure 1. Crankshaft and Related Parts

CLEANING

1. Handle crankshaft with care to avoid possible fractures or damage to finished surfaces. Clean crankshaft with solvent, then blow out all oil passages with compressed air.
2. Use crocus cloth to remove sharp edges or burrs which might damage oil seal or bearing during installation or cause premature seal or bearing wear. DO NOT use crocus cloth to extent that seal surface becomes polished. A finely polished surface may produce poor sealing or cause premature seal wear.
3. If journals are severely marred or exceed wear limit, refinish to size for next undersize bearing.

REFINISHING JOURNALS

1. Refinish journals to give proper clearance with next undersize bearing. If journal will not clean up to maximum undersize bearing available, replace crankshaft.
2. After refinishing journals, chamfer oil holes, then polish journal with No. 320 grit polishing cloth and engine oil. Crocus cloth also may be used as a polishing agent.

INSPECTION

1. Inspect main and connecting rod journals for cracks, scratches, grooves or scores. Inspect crankshaft oil seal

surface for nicks, sharp edges or burrs which might damage oil seal during installation or cause premature seal wear.
2. Measure diameter of each journal in at least 4 places to determine out-of-round, taper or undersize condition. (Figure 2)

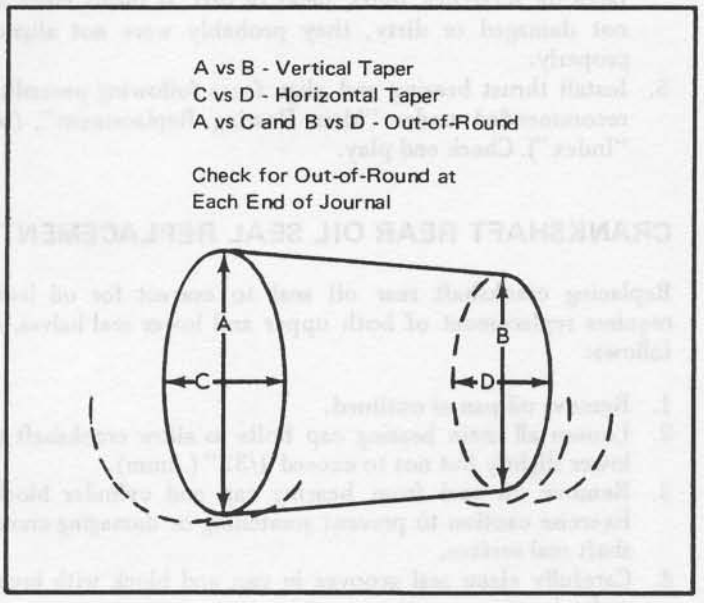

Figure 2. Crankshaft Journal Measurement

INSTALLATION

1. Remove rear journal oil seal from block and rear main bearing cap.
2. Remove main bearing inserts from block and bearing caps.
3. Remove connecting rod bearing inserts from connecting rods and caps.
4. If crankshaft main bearing journals are refinished to a definite undersize, install correct undersize bearings. Be sure that bearing inserts and bores are clean. Foreign material under inserts will distort bearing and cause a failure.
5. Place upper main bearing inserts in position in bores with tang fitting in slot provided.
6. Install lower main bearing inserts in bearing caps.
7. Install crankshaft rear oil seal as outlined.
8. Carefully lower crankshaft into place. Be careful not to damage bearing surfaces.
9. After bearings are fitted, apply a light coat of engine oil to journals and bearings. Install new seal in rear main bearing cap and install rear main bearing cap by following steps under "Main Bearing Replacement" (see "Index"). Install all bearing caps, except thrust bearing cap (No. 3 bearing). Be sure that main bearing caps are installed in their original locations. Torque bearing cap bolts to specifications.
10. Install thrust bearing cap with bolts finger-tight.
11. Pry crankshaft forward against thrust surface of upper half of bearing. (Figure 3)
12. Hold crankshaft forward and pry thrust bearing cap to rear to align thrust surfaces of both halves of bearing.
13. Retain forward pressure on crankshaft. Tighten cap bolts to specifications.
14. Force crankshaft toward rear of engine.
15. Check crankshaft end play.
16. Install new bearing inserts in connecting rods and caps. Check clearance of each bearing following recommended procedure.
17. After fitting connecting rod bearings, apply a light coat of engine oil to journals and bearings.
18. Turn crankshaft throw to bottom of its stroke. Push piston all the way down until rod bearing seats on crankshaft journal.
19. Install connecting rod cap and torque nuts to specifications.
20. After installing piston and connecting rod assemblies, check side clearance between connecting rods on each connecting rod crankshaft journal. (Figure 4)
21. Install timing chain and sprockets.
22. Install cylinder block front cover.
23. Install oil pump and oil pan.
24. Remove engine from stand and install flywheel.
25. Install spark plugs.

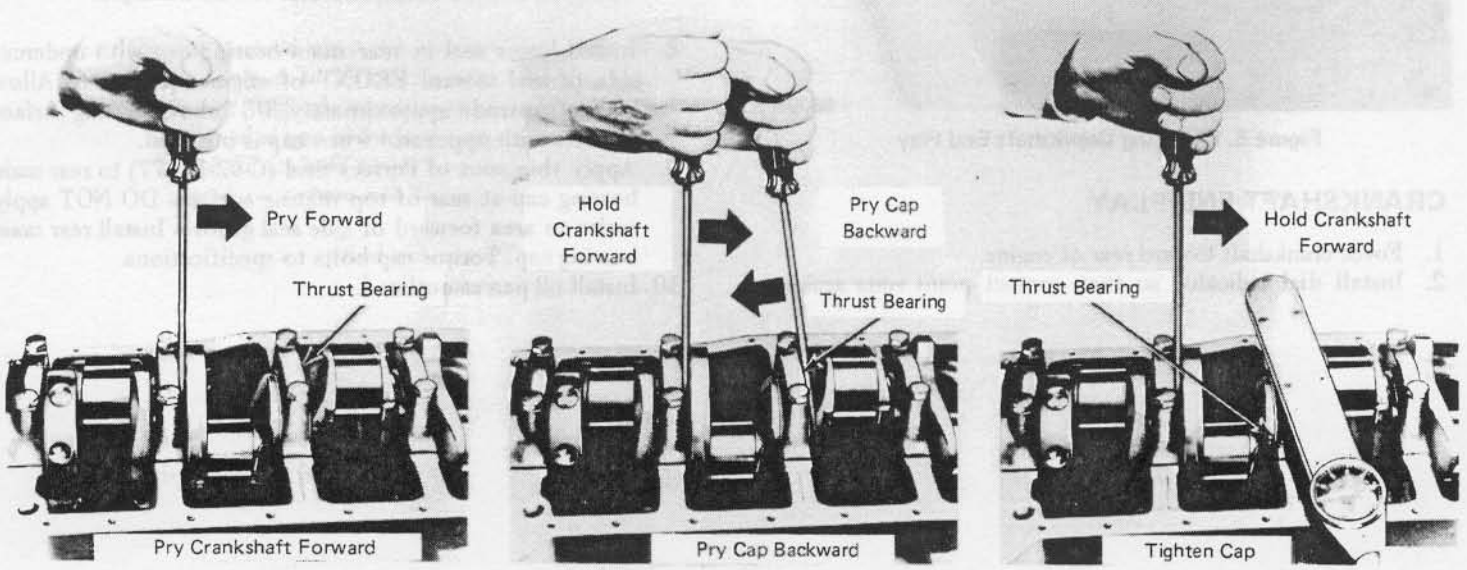

Figure 3. Aligning Thrust Bearing

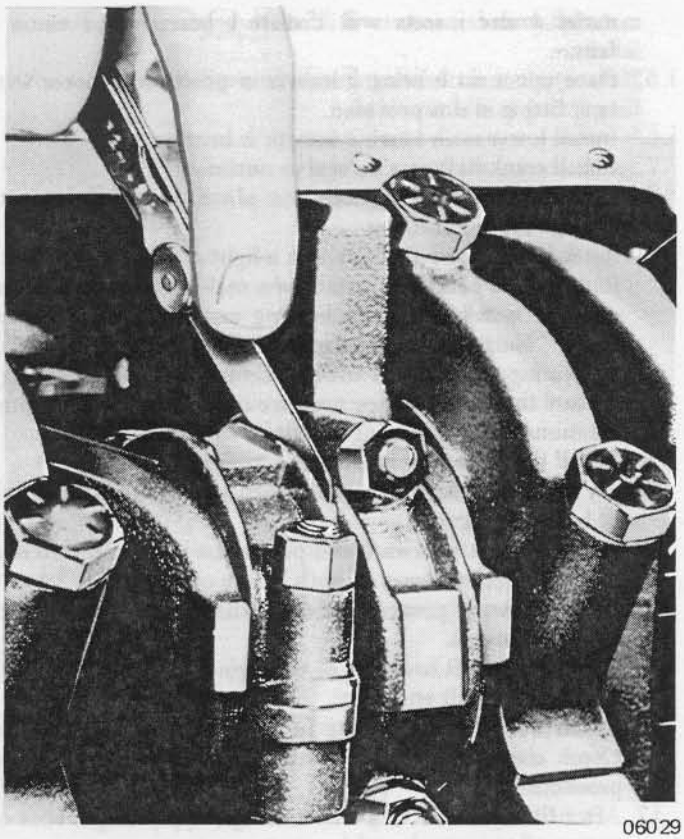

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Figure 4. Checking Connecting Rod Side Clearance

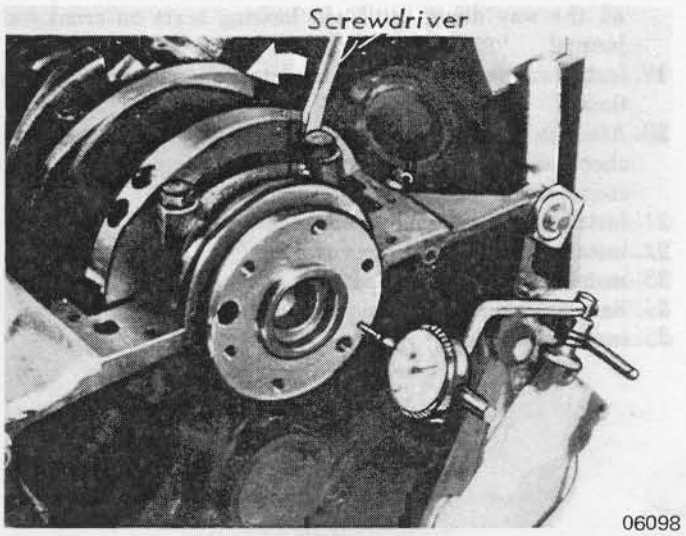

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Figure 5. Checking Crankshaft End Play

CRANKSHAFT END PLAY

1. Force crankshaft toward rear of engine.
2. Install dial indicator so that contact point rests against crankshaft flange and indicator axis is parallel to crankshaft axis. (Figure 5)
3. Zero dial indicator. Push crankshaft forward and note reading on dial.
4. If end play exceeds wear limit, replace thrust bearing. If end play is less than minimum limit, inspect thrust bearing faces for scratches, burrs, nicks or dirt. If thrust faces are not damaged or dirty, they probably were not aligned properly.
5. Install thrust bearing and align faces following procedure recommended under "Main Bearing Replacement", (see "Index"). Check end play.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Replacing crankshaft rear oil seal to correct for oil leaks requires replacement of both upper and lower seal halves, as follows:

1. Remove oil pan as outlined.
2. Loosen all main bearing cap bolts to allow crankshaft to lower slightly but not to exceed 1/32" (.8mm).
3. Remove oil seal from bearing cap and cylinder block. Exercise caution to prevent scratching or damaging crankshaft seal surface.
4. Carefully clean seal grooves in cap and block with brush and solvent.
5. Dip split-lip type seal halves in clean engine oil.
6. Carefully install upper seal (cylinder block) into its groove with undercut side of seal toward FRONT of engine, (Figure 6) by rotating it on seal journal of crankshaft until approximately 3/8" (9.5mm) protrudes below parting surface.

   IMPORTANT: Be sure that no rubber has been shaved from outside diameter of seal by bottom edge of groove.

7. Tighten remaining bearing cap bolts and torque to specifications.

   IMPORTANT: Split-lip seals are used as replacement seals. If rear main bearing cap has a rear seal retaining pin, pin must be removed or split-lip seal will be damaged.

8. Install lower seal in rear main bearing cap with undercut side of seal toward FRONT of engine. (Figure 6) Allow seal to protrude approximately 3/8" above parting surface to mate with upper seal when cap is installed.
9. Apply thin coat of Perfect Seal (C-92-34277) to rear main bearing cap at rear of top mating surface. DO NOT apply sealer to area forward of side seal groove. Install rear main bearing cap. Torque cap bolts to specifications.
10. Install oil pan as outlined.

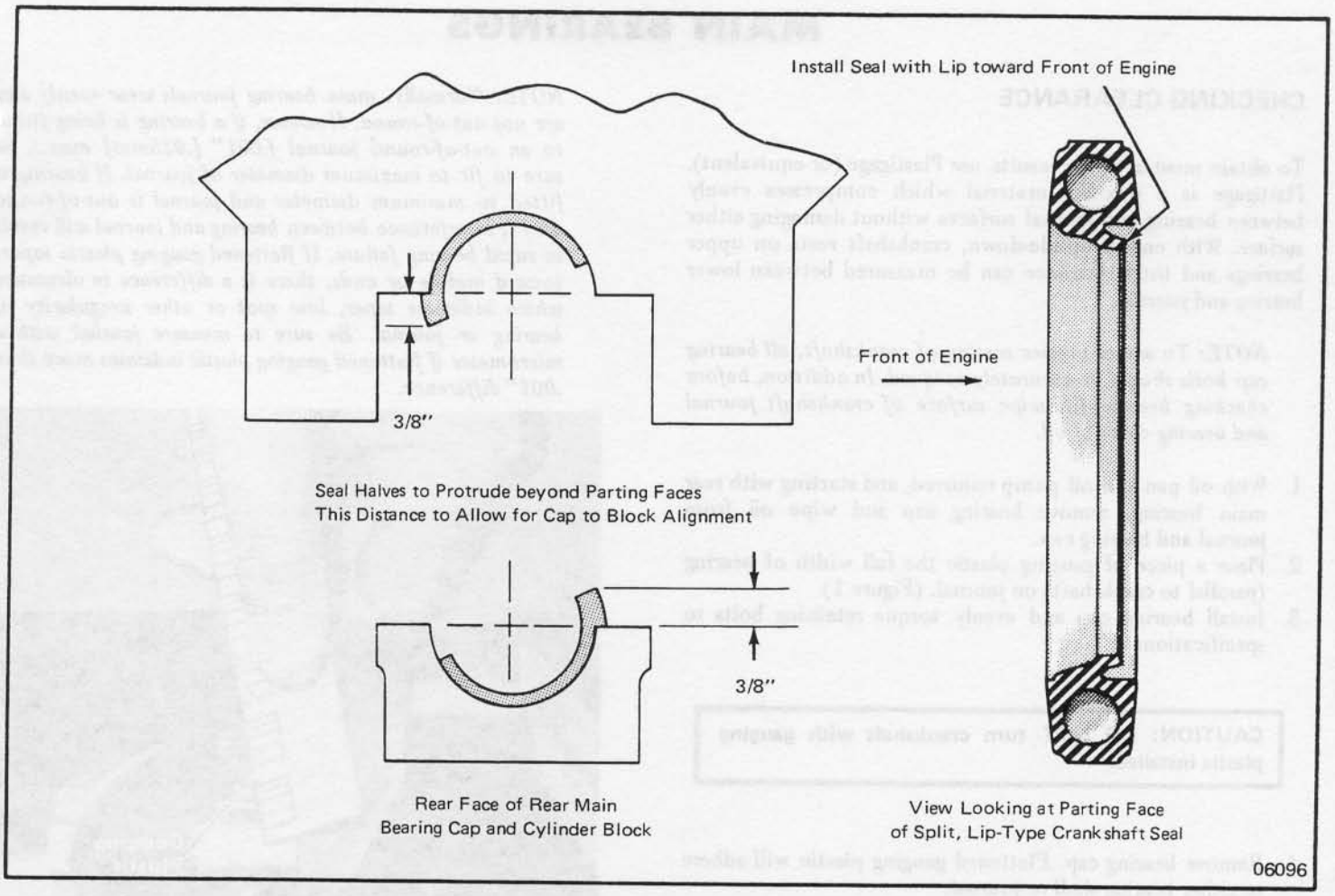


Figure 6. Installing Crankshaft Rear Seal

MAIN BEARINGS

CHECKING CLEARANCE

To obtain most accurate results, use Plastigage (or equivalent). Plastigage is a wax-like material which compresses evenly between bearing and journal surfaces without damaging either surface. With engine upside-down, crankshaft rests on upper bearings and total clearance can be measured between lower bearing and journal.

NOTE: To assure proper seating of crankshaft, all bearing cap bolts should be accurately torqued. In addition, before checking bearing fit, wipe surface of crankshaft journal and bearing clean of oil.

1. With oil pan and oil pump removed, and starting with rear main bearing, remove bearing cap and wipe oil from journal and bearing cap.
2. Place a piece of gauging plastic the full width of bearing (parallel to crankshaft) on journal. (Figure 1)
3. Install bearing cap and evenly torque retaining bolts to specifications.

CAUTION: DO NOT turn crankshaft with gauging plastic installed.

4. Remove bearing cap. Flattened gauging plastic will adhere to either bearing shell or journal.
5. Graduated scale on edge of gauging plastic envelope is correlated in thousandths of an inch. Without removing gauging plastic, measure its compressed width (at widest point) with graduations on gauging plastic envelope. (Figure 2)

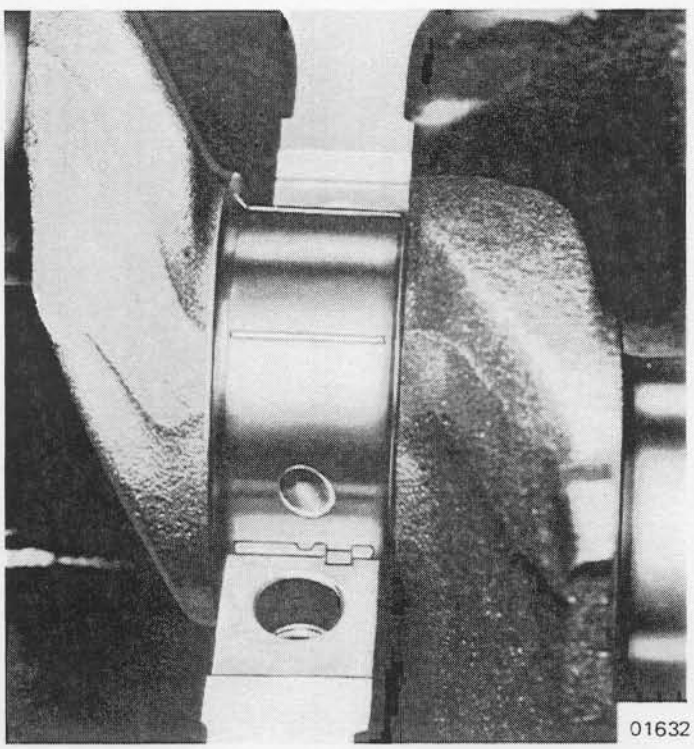


Figure 1. Gauging Plastic on Journal

NOTE: Normally, main bearing journals wear evenly and are not out-of-round. However, if a bearing is being fitted to an out-of-round journal (.001" [.025mm] max.), be sure to fit to maximum diameter of journal. If bearing is fitted to minimum diameter and journal is out-of-round .001", interference between bearing and journal will result in rapid bearing failure. If flattened gauging plastic tapers toward middle or ends, there is a difference in clearance which indicates taper, low spot or other irregularity of bearing or journal. Be sure to measure journal with a micrometer if flattened gauging plastic indicates more than .001" difference.

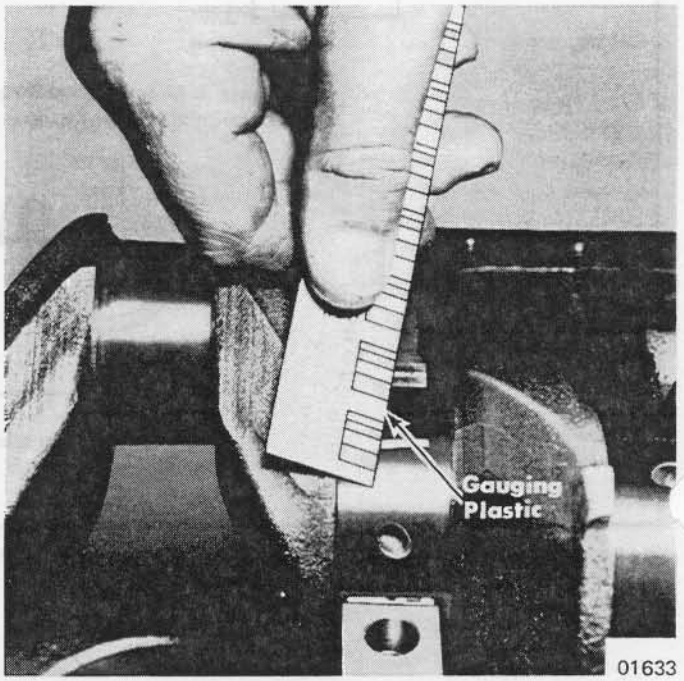


Figure 2. Measuring Gauging Plastic

6. If bearing clearance is within specifications, bearing insert is satisfactory. If clearance is not within specifications, replace insert. Always replace both upper and lower insert as a unit.

NOTE: If a new bearing cap is being installed and clearance is less than .001", inspect for burrs or nicks. If none is found, then install shims as required.

7. A standard .001" or .002" [.025 or .05mm] undersize bearing may produce proper clearance. If not, regrind crankshaft journal for use with next undersize bearing.
8. Proceed to next bearing. After all bearings have been checked, rotate crankshaft to see that there is no excessive drag.
9. Measure crankshaft end play with a dial indicator as outlined in crankshaft section (see "Specifications").
10. Install new rear main bearing oil seal in cylinder block and main bearing cap.

REPLACEMENT

1. Remove and inspect crankshaft.

2. Remove main bearings from cylinder block and main bearing caps.
3. Coat bearing surfaces of new, correct size, main bearings with oil and install in cylinder block and main bearing caps.
4. Install crankshaft.

CONNECTING ROD BEARINGS

Connecting rod bearings are precision insert type and do not utilize shims for adjustment. DO NOT FILE RODS OR ROD CAPS. If clearances are found to be excessive, a new bearing will be required. Bearings are available in standard size and .001" and .002" (.025 and .05mm) undersize for new and used standard size crankshafts, and in .010" and .020" (.254 and .51mm) undersize for reconditioned crankshafts.

CHECKING CLEARANCE and REPLACEMENT

1. With oil pan and oil pump removed, remove connecting rod cap and bearing.
2. Inspect bearing for evidence of wear or damage. Do not reinstall defective bearings.
3. Wipe bearings and crankpin clean of oil.
4. Measure crankpin for out-of-round or taper with a micrometer. If not within specifications, replace or recondition crankshaft. If within specifications and a new bearing is to be installed, measure maximum diameter of crankpin to determine new bearing size required.
5. If within specifications, measure new or used bearing clearances with Plastigage or equivalent.

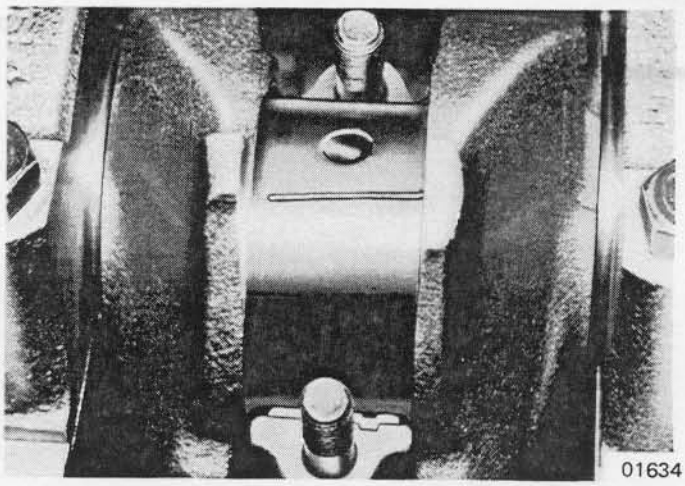


Figure 3. Plastigage on Crankpin

NOTE: If a bearing is being fitted to an out-of-round crankpin, be sure to fit to maximum diameter of crankpin. If bearing is fitted to minimum diameter, and crankpin is out-of-round .001" (.025mm), interference between bearing and crankpin will result in rapid bearing failure.

   a. Place a piece of gauging plastic the full width of crankpin (parallel to crankshaft). (Figure 3)
   b. Install bearing in connecting rod and cap.
   c. Install bearing cap and torque nuts evenly to specifications.

CAUTION: Do not turn crankshaft with gauging plastic installed.

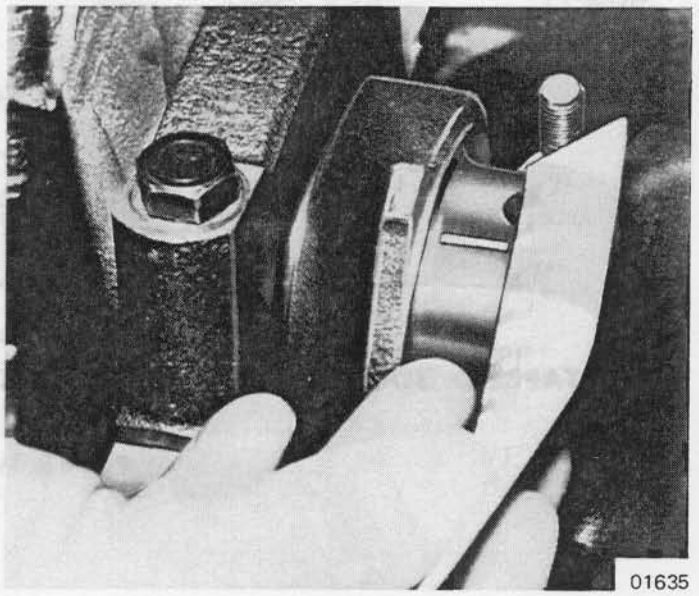


Figure 4. Measuring Plastigage on Crankpin

   d. Remove bearing cap and, using scale on gauging plastic envelope, measure gauging plastic width at widest point. (Figure 4)
6. If clearance exceeds specifications, select a new, correct size bearing and remeasure clearance.
7. Coat bearing surface with oil, install rod cap and torque nuts to specifications.
8. When all connecting rod bearings have been installed, tap each rod lightly (parallel to crankpin) to assure clearance.
9. Measure all connecting rod side clearances (see specifications in Section 8) between connecting rod cap(s).

NOTE: Refer to "Piston Assembly - Installation" (see "Index").

MAIN and CONNECTING ROD BEARING INSERTS

CLEANING

Clean bearing inserts and caps thoroughly in solvent and dry with compressed air. DO NOT **scrape gum or varnish deposits from bearing shells.**

INSPECTION

Inspect each bearing carefully. Replace bearings with scored, chipped or worn surface. Typical examples of unsatisfactory bearings and causes are shown in Figure 5. Check clearance of used and new bearings with Plastigage.

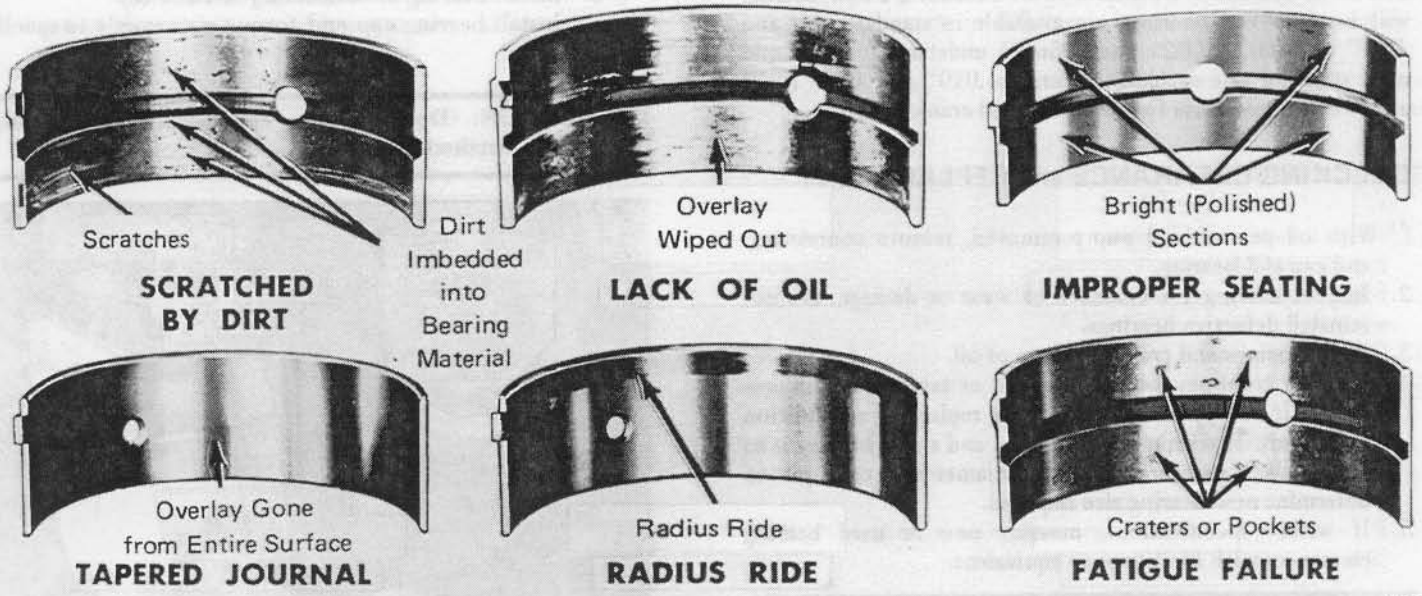


Figure 5. Typical Bearing Failures

TORSIONAL DAMPER

REMOVAL

1. Remove alternator belt.
2. Remove pulley by removing 3 attaching bolts.
3. Remove torsional damper retaining bolt.
4. Install Tool T58P-6316A and T62F-6316B and pull off torsional damper. (Figure 1)

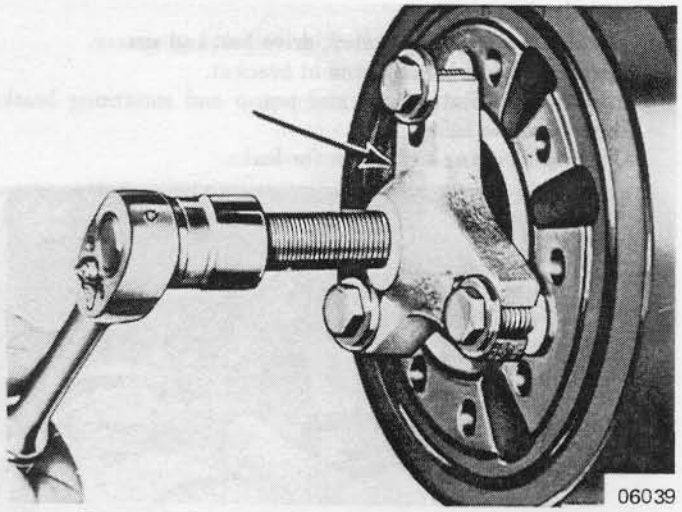


Figure 1. Removing Crankshaft Vibration Damper

CLEANING

1. Clean oil seal contact surface on crankshaft damper or sleeve with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits, that are not readily removed with solvent, may be removed with crocus cloth.
2. Use crocus cloth to remove any sharp edges or burrs which might damage the oil seal during installation or cause premature seal wear. **DO NOT use crocus cloth to polish seal surface. A finely polished surface may produce poor sealing or cause premature seal wear.**

INSPECTION

Inspect crankshaft damper or sleeve oil seal surface for nicks, sharp edges or burrs that might damage oil seal during installation or cause premature seal wear.

INSTALLATION

CAUTION: Inertia weight section of torsional damper is assembled to hub with a rubber type material. Installation procedures (with proper tool) must be followed, or movement of inertia weight section on hub will destroy tuning of torsional damper.

1. Pull torsional damper onto crankshaft with tool T52L-6306-AEE. (Figure 2)
2. Install retaining bolt and washer. Torque to specifications.
3. Install pulley and alternator belt.

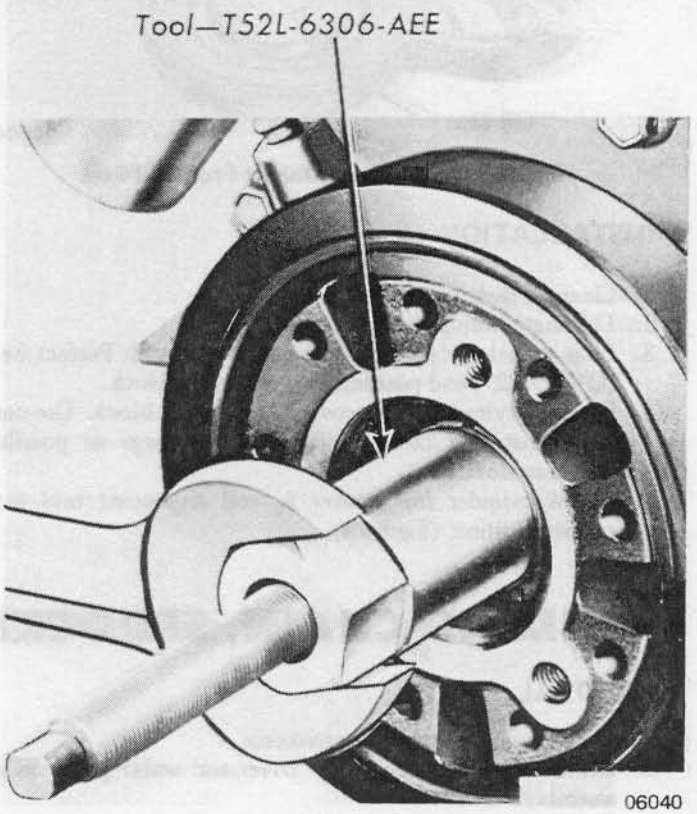


Figure 2. Installing Crankshaft Vibration Damper

CYLINDER BLOCK FRONT COVER and FRONT SEAL

REMOVAL

1. Drain water and oil from engine.
2. Remove oil pan as outlined.
3. Remove alternator adjustment bracket.
4. Remove alternator and seawater pump as an assembly by removing mounting bracket from cylinder block front cover.
5. Remove circulating water pump pulley and drive belt.
6. Remove torsional damper as outlined.
7. Remove fuel filter and fuel pump.
8. Remove cylinder block front cover and water pump as an assembly. Transfer water pump to new cylinder block front cover, if cover is being replaced.
9. Discard cylinder block front cover gasket.

FRONT OIL SEAL REPLACEMENT

1. Drive out old seal with a pin-punch. Clean out recess in cover.
2. Coat new seal with grease, then install seal in cover. Drive seal in until fully seated in recess. (Figure 3) Check seal after installation to be sure that spring is properly positioned in seal.

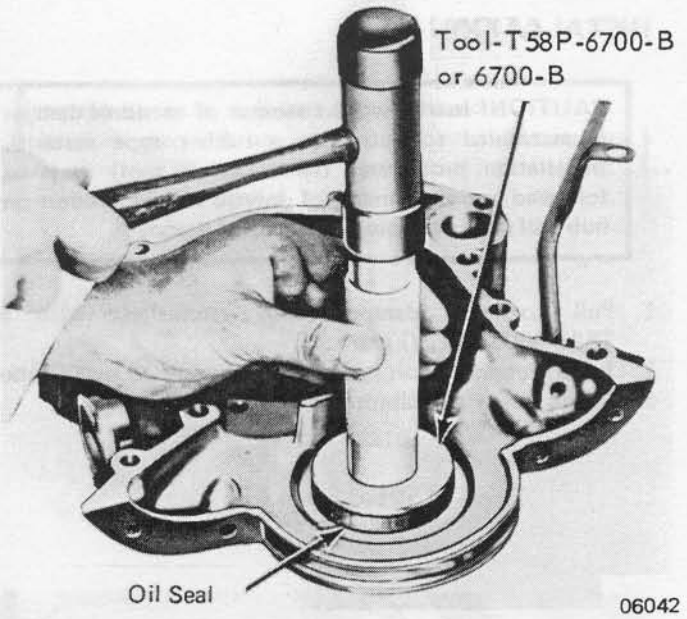


Figure 3. Installing Crankshaft Front Oil Seal

INSTALLATION

1. Clean all gasket surfaces.
2. Lubricate timing chain with engine oil.
3. Coat gasket surfaces of block and cover with Perfect Seal (C-92-34227) and position new gasket on block.
4. Position cylinder front cover on cylinder block. Use care when installing cover to avoid seal damage or possible gasket mislocation.
5. Install cylinder front cover to seal alignment tool into proper position. (Figure 4)
6. Coat threads of attaching screws with Perfect Seal (C-92-34227) and install screws. Torque cover-to-block attaching screws to specifications. Remove pilot.
7. Apply Multipurpose Lubricant (C-92-49588 or C-92-63250) to oil seal lip and vibration damper oil seal rubbing surface to prevent damage to seal.
8. Line up crankshaft vibration damper keyway with key on crankshaft. Install vibration damper on crankshaft.
9. Install oil pan as outlined, preceding.
10. Install fuel pump, using a new gasket. Connect fuel pump outlet line.
11. Install water pump pulley, drive belt and spacer.
12. Install alternator adjustment bracket.
13. Install alternator, seawater pump and mounting bracket. Install drive belts.
14. Operate engine and check for leaks.

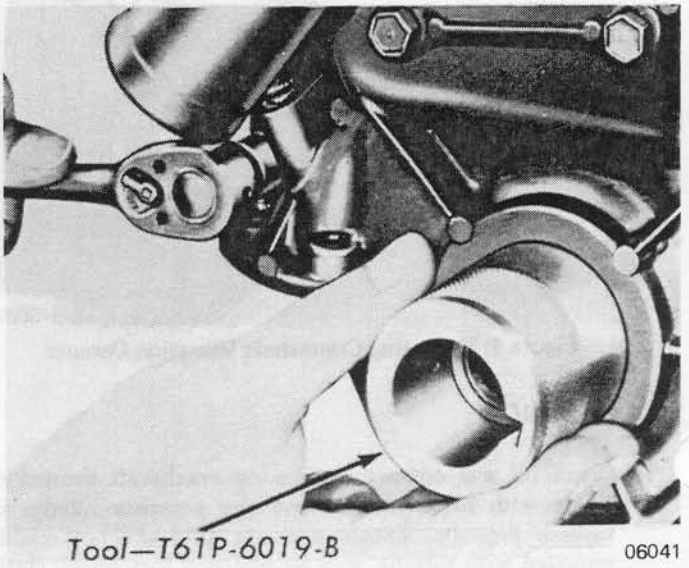


Figure 4. Front Cover Installation

TIMING CHAIN, SPROCKETS and FUEL PUMP ECCENTRIC

REMOVAL

1. Drain cooling system and crankcase.
2. Remove cylinder block front cover and water pump as an assembly.
3. Slide off crankshaft front oil slinger.
4. Check timing chain deflection. Refer to "Timing Chain Deflection", following.
5. Crank engine until timing marks on sprockets are positioned as shown in Figure 7.
6. Remove crankshaft sprocket cap screw, washers and fuel pump eccentric. Slide both sprockets and timing chain forward and remove as an assembly.

TIMING CHAIN and SPROCKETS

CLEANING

1. Clean all parts in solvent and dry with compressed air.
2. Lubricate timing chain with engine oil before installing on engine.

INSPECTION

1. Inspect chain for broken links.
2. Inspect sprockets for cracks, scores, nicks and worn or damaged teeth.
3. Replace all components of timing chain and sprocket assembly if any one item needs replacement.

FUEL PUMP ECCENTRIC

CLEANING

Clean fuel pump eccentric in solvent and dry with compressed air.

INSPECTION

Inspect fuel pump drive eccentric for scores, nicks and excessive wear. Replace eccentric if scored.

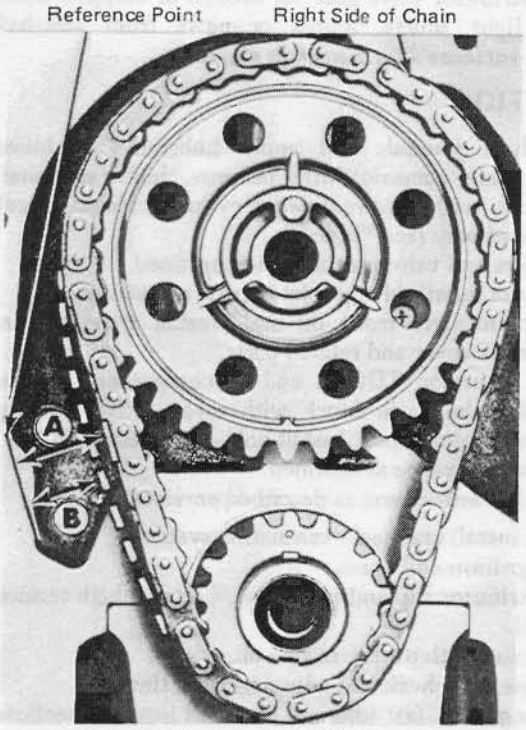
TIMING CHAIN DEFLECTION

1. Rotate crankshaft in clockwise direction (as viewed from front) to take up slack on left side of chain.
2. Establish a reference point on cylinder block and measure from this point to chain (Figure 5)
3. Rotate crankshaft in opposite direction to take up slack on right side of chain. Force left side of chain out with fingers and measure distance between reference point and chain. The deflection is difference between the 2 measurements.

If deflection exceeds specifications, replace timing chain and sprockets.

INSTALLATION

1. Position sprockets and timing chain on camshaft. (Figure 6) Be sure that timing marks on sprockets are positioned as shown in Figure 7.
2. Install fuel pump eccentric, washers and camshaft sprocket cap screw. Torque cap screw to specifications and install crankshaft oil slinger. (Figure 8)



Take Up Slack on Left Side; Establish Reference Point. Measure Distance "A". Take Up Slack on Right Side. Force Left Side Out. Measure Distance "B". Deflection Is "A" Minus "B".

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Figure 5. Checking Timing Chain Deflection

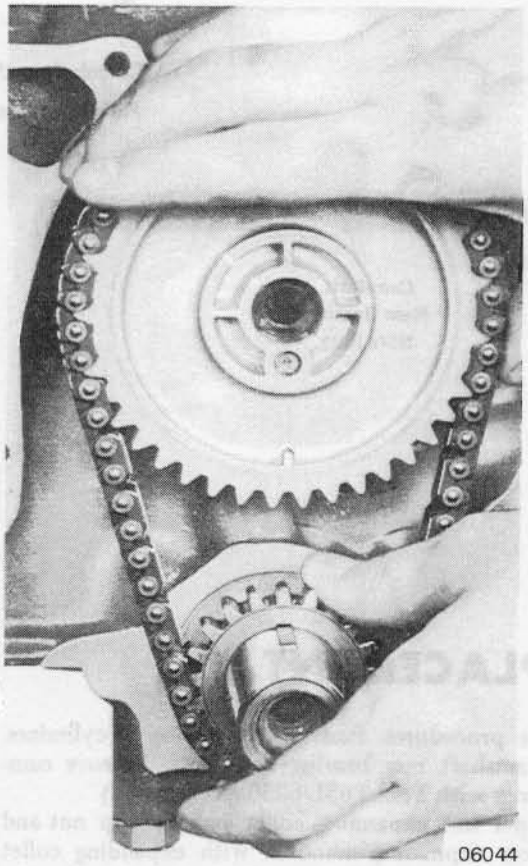

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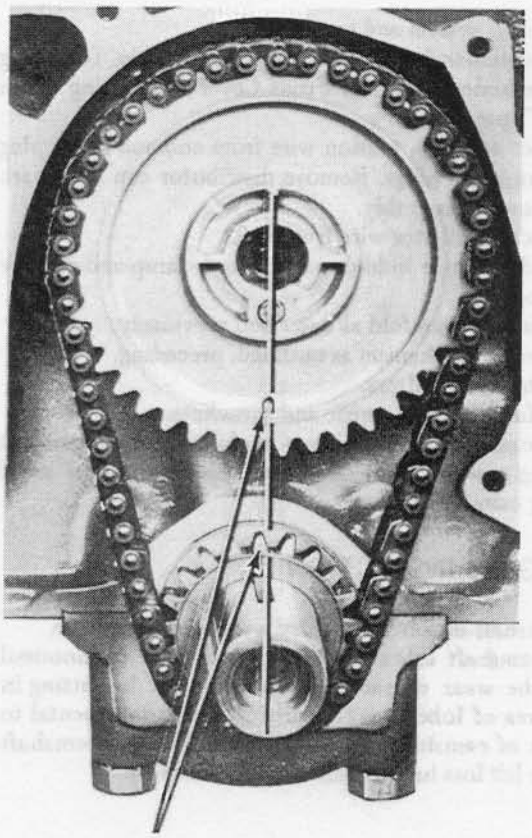
Figure 6. Removing or Installing Timing Chain



Timing Marks

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Figure 7. Aligning Timing Marks

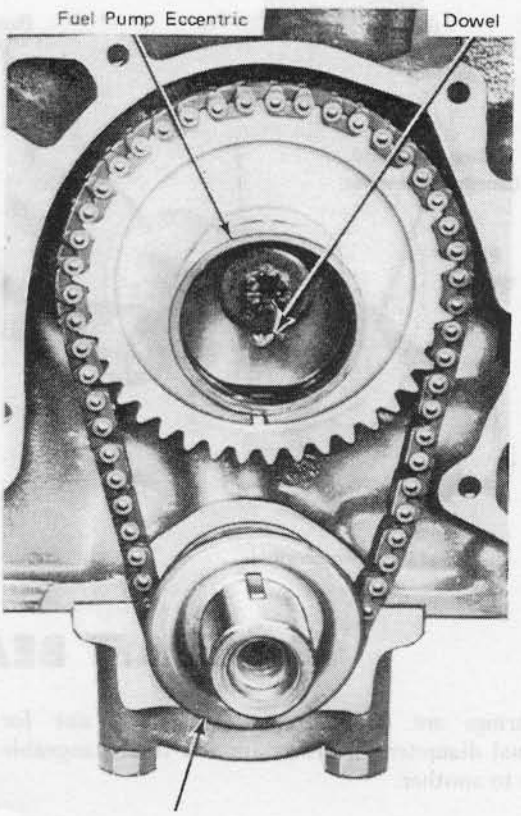

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Figure 8. Fuel Pump Eccentric and Front Oil Slinger Installed

CAMSHAFT

Camshaft and related parts are shown in Figure 1.

REMOVAL

1. Drain cooling system and crankcase.
2. Remove cylinder front cover and timing chain, following procedure under "Cylinder Front Cover and Timing Chain Removal", preceding.
3. Disconnect coil high tension wire from coil and spark plug wires from spark plugs. Remove distributor cap and spark plug wires as an assembly.
4. Disconnect distributor wire from coil.
5. Remove distributor hold-down bolt and clamp and remove distributor.
6. Remove intake manifold as described previously.
7. Remove valve mechanism as outlined, preceding.
8. Remove hydraulic lifters.
9. Remove fuel pump eccentric and sprockets.
10. Remove camshaft thrust plate. Carefully remove camshaft by pulling toward front of engine. Use caution to avoid damaging camshaft bearings.

CLEANING and INSPECTION

1. Clean camshaft in solvent and dry with compressed air.
2. Inspect camshaft lobes for scoring and signs of abnormal wear. Lobe wear characteristics may result in pitting in general area of lobe toe. This pitting is not detrimental to operation of camshaft, therefore, do not replace camshaft until lobe lift loss has exceeded .005" (.13mm).
3. Check lift of camshaft lobes with camshaft installed in engine or on "V" blocks. Refer to "Camshaft Lobe Lift" (see "Index").
4. Check distributor drive gear for broken or chipped teeth.
5. Remove light scuffs, scores or nicks from camshaft machined surfaces with a smooth oil stone.

INSTALLATION

1. Oil camshaft journals and apply Lubriplate to lobes. Carefully slide camshaft thru bearings. Install camshaft thrust plate with groove toward cylinder block. Check camshaft end play (see "Index").
2. Install lifters and valve mechanism as outlined.
3. Install intake manifold and related parts as outlined.
4. Replace crankshaft front oil seal. Install timing chain, cylinder front cover and related parts.
5. With No. 1 piston TDC at end of compression stroke, position distributor in block with rotor at No. 1 firing position and points open. Install hold-down clamp.
6. Check valve clearance as outlined.
7. Install rocker arm covers as described previously.
8. Clean and install crankcase ventilation system.
9. Connect ignition coil wires.
10. Install distributor cap and plug wires. Connect high tension lead at coil.
11. Fill crankcase with proper engine oil.
12. Start engine and check and adjust ignition timing.
13. Operate engine at fast idle and check all hose connections and gaskets for leaks. When engine temperature has stabilized, adjust engine idle speed and idle fuel mixture.

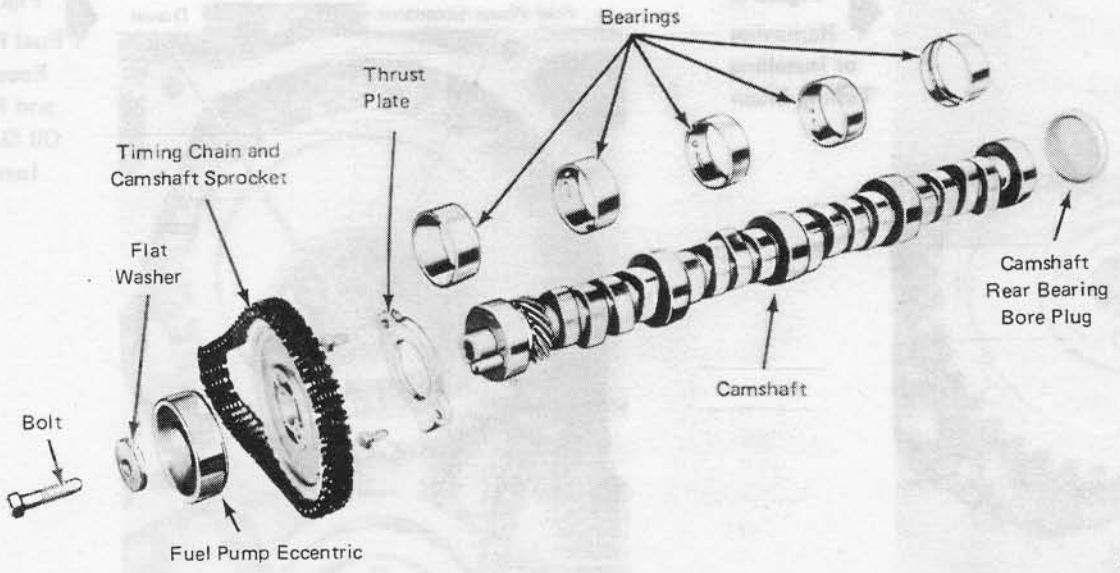

Figure 1. Camshaft and Related Parts

CAMSHAFT BEARING REPLACEMENT

Camshaft bearings are available pre-finished to size for standard journal diameters. Bearings are not interchangeable from one bore to another.

1. Remove camshaft, flywheel and crankshaft, following appropriate procedures. Push pistons to top of cylinders.
2. Remove camshaft rear bearing bore plug. Remove camshaft bearings with Tool T65L-6250-A. (Figure 2)
3. Select proper size expanding collet and back-up nut and assemble on expanding mandrel. With expanding collet

collapsed, install collet assembly in camshaft bearing and tighten back-up nut on expanding mandrel until collet fits camshaft bearing.

NOTE: Camshaft bearing diameters vary. Replacement bearings are numbered according to location in cylinder block. No. 1 bearing is at front of block.

4. Assemble puller screw and extension (if necessary) as shown and install on expanding mandrel. Wrap a cloth around threads of puller screw to protect front bearing or journal. Tighten pulling nut against thrust bearing and pulling plate to remove camshaft bearing. Be sure to hold a wrench on end of puller screw to prevent screw from turning.
5. Repeat procedure for each bearing. To remove front bearing, install puller screw from rear of cylinder block.
6. Position new bearings at bearing bores with oil holes aligned and press in place with tool shown in Figure 2. Be sure to center pulling plate and puller screw to avoid damage to bearing. Failure to use correct expanding collet can cause severe bearing damage. Be sure that front bearing is installed .005" to .020" (.13 to .51mm) below front face of cylinder block. (Figure 3)
7. Install core plug. (Figure 4)
8. Install camshaft, crankshaft, flywheel and related parts, following appropriate procedures.

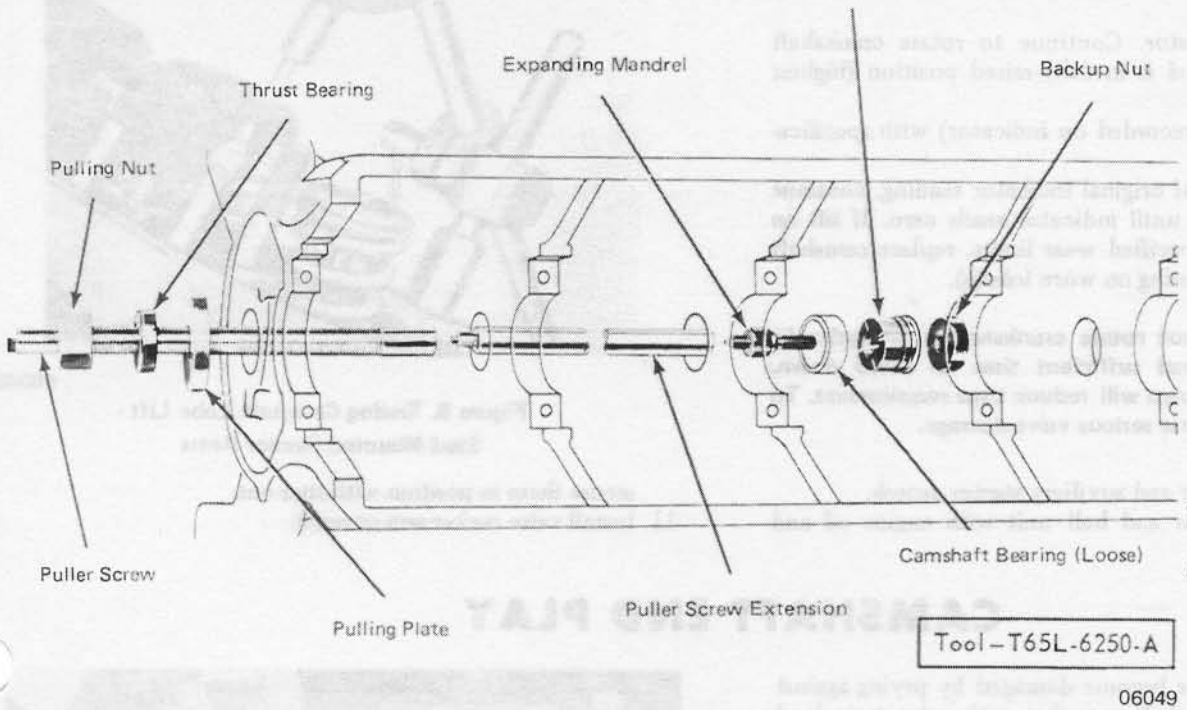

Figure 2. Camshaft Bearing Replacement

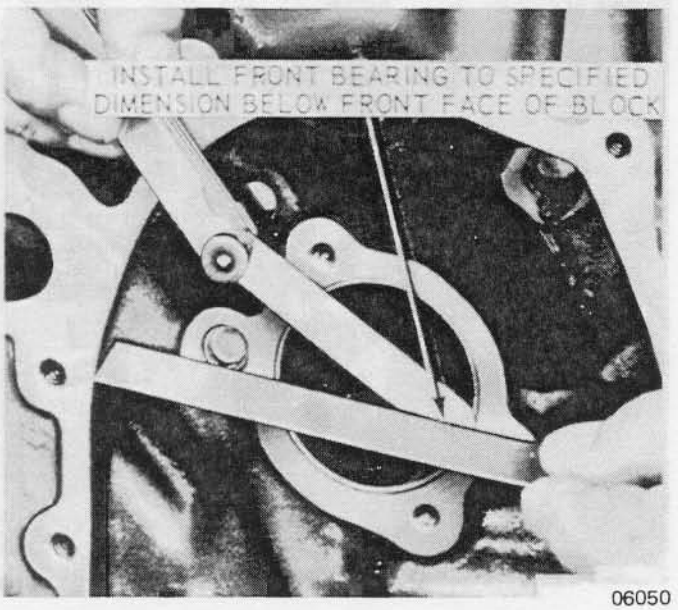

Figure 3. Camshaft Front Bearing Measurement

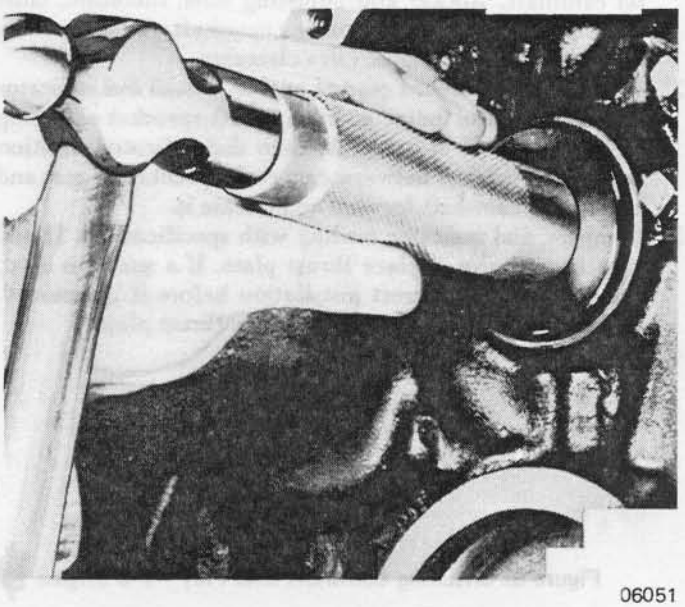

Figure 4. Installing Camshaft Bearing Plug

CAMSHAFT LOBE LIFT

Check lift of each lobe in consecutive order and make a note of readings.

1. Remove valve rocker arm cover(s).
2. Remove rocker arm stud nut, ball unit and rocker arm. Use adaptor for ball-end push rods.
3. Be sure that push rod is in valve lifter socket. Install dial indicator so that ball socket adaptor of indicator is on end of push rod and in same plane as push rod movement. (Figure 5)

4. Disconnect ignition coil.
5. Slowly turn crankshaft over until tappet or lifter is on low side of camshaft lobe. At this point, push rod will be in its lowest position.

IMPORTANT: An incorrect reading will be taken if hydraulic lifters have not had sufficient time to bleed down. Lifters may be manually bled down to ensure an accurate reading.

6. Zero the dial indicator. Continue to rotate crankshaft slowly until push rod is in fully-raised position (highest indicator reading).
7. Compare total lift (recorded on indicator) with specifications.
8. To check accuracy of original indicator reading, continue to rotate crankshaft until indicator reads zero. If lift on any lobe is below specified wear limits, replace camshaft and valve lifters operating on worn lobe(s).

IMPORTANT: Do not rotate crankshaft until hydraulic valve lifters have had sufficient time to bleed down. Manually bleeding down will reduce time requirement. To do otherwise may cause serious valve damage.

9. Remove dial indicator and auxiliary starter switch.
10. Lubricate rocker arm and ball unit with engine oil and secure them in position with stud nut.
11. Install valve rocker arm cover(s).

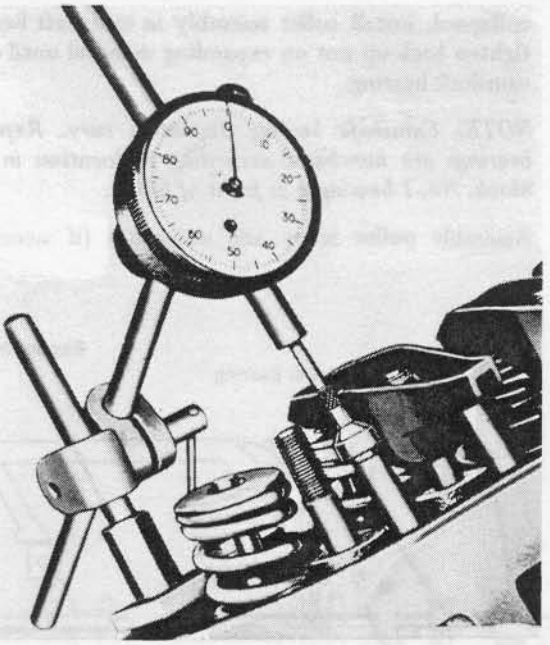

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Figure 5. Testing Camshaft Lobe Lift - Stud Mounted Rocker Arms

CAMSHAFT END PLAY

1. Sprocket can break or become damaged by prying against aluminum-nylon camshaft sprocket with valve train load on camshaft. Rocker arm adjusting nuts, therefore, must be backed off sufficiently to free camshaft. After checking camshaft end play, adjust valve clearance.
2. Push camshaft toward rear of engine. Install dial indicator so that indicator point is on camshaft sprocket attaching screw (Figure 6) or gear hub. Zero dial indicator. Position a large screwdriver between camshaft sprocket or gear and block. Pull camshaft forward and release it.
3. Compare dial indicator reading with specifications. If end play is excessive, replace thrust plate. If a spacer is used, check spacer for correct installation before it is removed. If spacer is correctly installed, replace thrust plate.
4. Remove dial indicator.

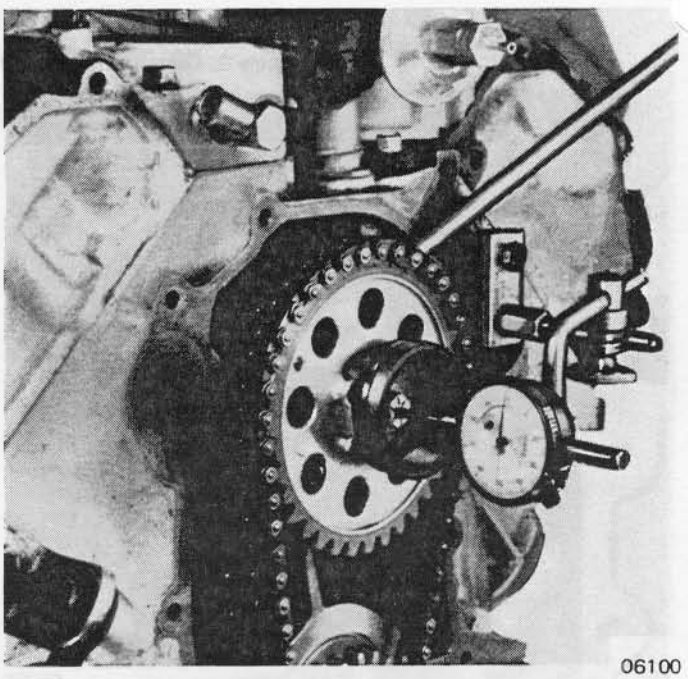

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Figure 6. Checking Camshaft End Play - V-8 Engine

CYLINDER BLOCK

CLEANING

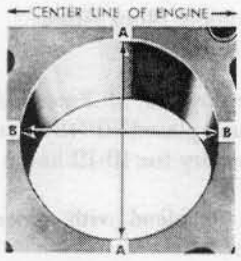
1. After any cylinder bore repair operation, such as honing or deglazing, clean bore(s) with soap or detergent and water. Then, thoroughly rinse bore(s) with clean water to remove soap or detergent and wipe bore(s) dry with a clean, lint-free cloth. Finally, wipe bore(s) with a clean cloth dipped in engine oil. If these procedures are ignored, cylinder bore(s) may rust.
2. If engine is disassembled, thoroughly clean block with solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs that seal oil passages, then

clean all passages. Blow out all passages, bolt holes, etc, with compressed air.

3. Be sure that threads in cylinder head bolt holes are clean. Dirt in threads may cause binding and result in a false torque reading. Use a tap to true-up threads and to remove any deposits.
4. Thoroughly clean grooves in crankshaft bearing and bearing retainers.

INSPECTION

1. After thoroughly cleaning block, check for cracks. Minute cracks (not visible to naked eye) may be detected by coating suspected area with mixture of 25% kerosene and 75% light engine oil. Wipe part dry and immediately apply coating of zinc oxide dissolved in wood alcohol. If cracks are present, coating will become discolored at defective area. Replace block, if it is cracked.
2. Check all machined gasket surfaces for burrs, nicks, scratches and scores. Remove minor imperfections with an oil stone.
3. Check cylinder block for flatness of cylinder head gasket surface following procedure and specifications recommended for cylinder head. Cylinder block can be machined to bring cylinder head gasket surface within flatness specifications, but not to exceed .010" (.254mm).
4. Replace all expansion-type plugs with evidence of leakage.
5. Inspect cylinder walls for scoring, roughness or other signs of wear. Check cylinder bore for out-of-round and taper. Measure bore with an accurate bore gauge, following instructions of the manufacturer. Measure diameter of each cylinder bore at top, middle and bottom with gauge placed at right angles and parallel to center line of engine. (Figure 7) Use only measurements obtained at 90° to engine centerline when calculating piston to cylinder bore clearance.



"A" = At right angle to centerline of engine
"B" = Parallel to centerline of engine
"Out-of-round" = Difference between "A" and "B"
"Taper" = Difference between measurement at top of cylinder bore and "A" measurement at bottom of cylinder bore.

Figure 7. Cylinder Bore Out-of-Round and Taper

6. Refinish cylinders which are deeply scored and/or when out-of-round and/or taper exceeds wear limits.
7. If cylinder walls have minor surface imperfections, but out-of-round and taper are within limits, it may be possible to remove imperfections by honing cylinder walls and installing new service piston rings, if piston clearance is within specified limits.

REFINISHING CYLINDER WALLS

1. Honing is recommended for refinishing cylinder walls only when walls have minor scuffs or scratches, or for fitting pistons to specified clearance. The grade of hone is determined by amount of metal to be removed. Follow instructions of hone manufacturer. If coarse stones are used to start honing operation, leave enough material so that all hone marks can be removed with finishing hone which is used to obtain proper piston clearance.
2. Refinish cylinder walls that are severely marred and/or worn beyond specified limits. Before any cylinder is refinished, all main bearing caps must be in place and tightened to proper torque so that crankshaft bearing bores will not become distorted from refinishing operation.
3. Refinish only damaged cylinder or cylinders. All pistons are same weight, both standard and oversize, therefore, various piston sizes can be used without upsetting engine balance.
4. To determine maximum oversize, refinish cylinder with most wear first. If cylinder will not clean up when refinished for maximum oversize piston, replace block.
5. Refinish cylinder to within approximately .0015" (.038mm) of required oversized diameter. This will allow enough stock for final step of honing so that correct surface finish and pattern are obtained.
6. For proper use of refinishing equipment, follow instructions of manufacturer. Only experienced personnel should perform this work.
7. Use a motor-driven, spring-pressure-type hone at a speed of 300-500 RPM. Hones of grit sizes 180-220 normally will provide desired bore surface.
   When honing cylinder bores, use a lubricant mixture of equal parts of kerosene and SAE No. 20 motor oil. Operate hone to produce a cross-hatch finish on cylinder bore. Cross-hatch pattern should be at an angle of approximately 30° to cylinder bore.
8. After final operation in either of 2 refinishing methods described, and prior to checking piston fit, thoroughly clean and oil cylinder walls.
9. Check piston fit following procedure in this section. Mark pistons to correspond to cylinders for reinstallation. When cylinder refinishing has been completed and all pistons are fitted, thoroughly clean entire block and oil cylinder walls following procedure under "Cylinder Block Cleaning", preceding.

FITTING PISTONS

1. Pistons are available for service in standard sizes and .003" and .020" (.076 and .508mm) oversizes.
2. Measure piston OD and cylinder bore. Dimensions should be within specifications, and piston to bore clearance (bore ID minus piston OD) must be within specified limits.
3. If clearance is greater than maximum limit, recheck calculations to be sure that proper-size piston has been selected or check for a damaged piston, then try a new piston.
4. If clearance is less than minimum limit, recheck calculations before trying another piston. If none can be fitted, refinish cylinder to provide correct piston clearance.

   NOTE: When a piston has been fitted, mark it for assembly in cylinder to which it was fitted.

5. If taper, out-of-round and piston-to-cylinder-bore clearance conditions of cylinder bore are within specified limits, new piston rings will give satisfactory service.
6. If installing new rings in a used cylinder, that has not been refinished, remove cylinder wall glaze (refer to "Cylinder Block, Refinishing Cylinder Walls", preceding). Be sure to clean cylinder bore thoroughly.

TO FIT A PISTON . . . .

1. Calculate size piston required by taking a cylinder bore check.
2. Select proper size piston to provide desired clearance (refer to specifications). Measure piston diameter in line with centerline of piston pin and at 90° to piston pin axis.
3. Make sure that piston and cylinder block are at room temperature (70° F). After any refinishing operation, allow cylinder bore to cool and make sure that piston and bore are clean and dry before piston fit is checked.

REPAIRING CYLINDER BLOCK

1. Porosity or sand hole(s), which cause oil seepage or leakage, can occur with modern casting processes. Make complete inspection of engine and transmission. If leak is attributed to porous condition of cylinder block or sand hole(s), make repairs with metallic plastic. DO NOT repair cracks with this material. Confine repairs to those cast iron engine component surfaces (Figure 8) where inner wall surface is not exposed to engine coolant pressure or oil pressure, for example:
   a. Cylinder block surfaces extending along length of block upward from oil pan rail to cylinder water jacket but not including machined areas.
   b. Lower rear face of cylinder block.
   c. Intake manifold casting. Repairs are not recommended to intake manifold exhaust crossover section, since temperatures can exceed recommended temperature limit of 500° F (272°C).
   d. Cylinder front cover on engines using cast iron material.
   e. Cylinder head, along rocker arm cover gasket surface.
2. Use following procedure to repair porous areas or sand holes in cast iron.
   a. Clean surface to be repaired by grinding or rotary filing to a clean bright metal surface. Chamfer or undercut hole or porosity to a greater depth than rest of cleaned surface. Solid metal must surround hole. Openings larger than ¼" (6.35mm) should not be repaired with metallic plastic. Openings in excess of ¼" can be drilled, tapped and plugged with common tools. Clean repair area thoroughly. Metallic plastic will not stick to a dirty or oil surface.
   b. Mix metallic plastic base and hardener as directed on container. Stir thoroughly until uniform.
   c. Apply repair mixture with a suitable clean tool (putty knife, wood spoon, etc), forcing epoxy into hole or porosity.

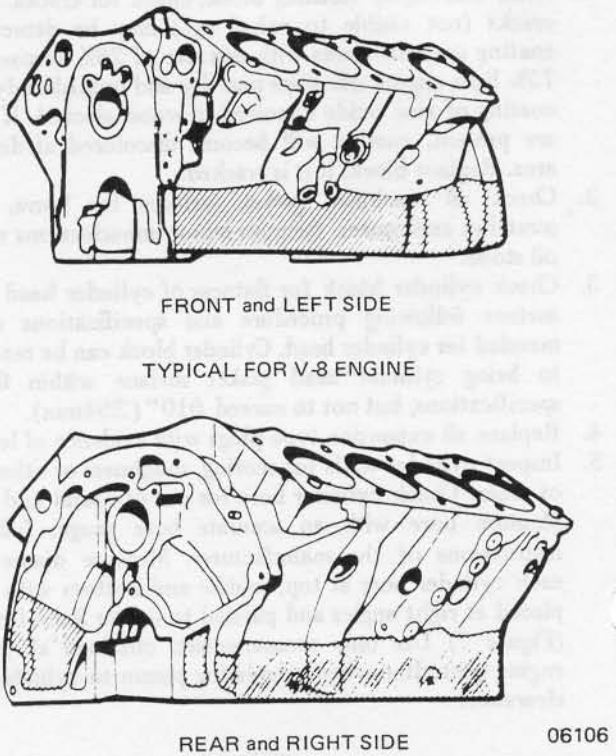


Figure 8. Typical Cast Iron Cylinder Block Areas Repairable with Metallic Plastic

   d. Allow repair mixture to harden by one of 2 methods: Heat cure with a 250° watt lamp placed 10" (25.4cm) from the repaired surface, or air dry for 10-12 hours at temperatures above 50° F (10°C).
   e. Sand or grind repaired area to blend with general contour of surrounding surface.
   f. Paint surface to match rest of block.

CORE PLUG REPLACEMENT

REMOVAL

1. To remove a large core plug, drill a ½" (12.7mm) hole in center of plug and pry it out with a large, drift punch.
2. On a small core plug, drill a ¼" (6.35mm) hole in center of plug and pry it out with a small pin punch. Clean and inspect plug bore.
3. Prior to installing a core plug, inspect plug bore for any damage that would interfere with proper sealing of plug. If bore is damaged, it is necessary to true surface by boring for next specified oversize plug.
4. Oversize (OS) plugs are identified by OS stamped in flat located on cup side of plug.
5. Coat plug and/or bore lightly with Perfect Seal (C-92-34227) and install per following procedure.

INSTALLATION

1. Install core plugs (Figure 9) with flanged edge out. Maximum diameter of this plug is located at outer (sealing) edge of flange.

IMPORTANT: Install plug into machined bore only with a properly designed tool. Under no circumstances is plug to be driven into bore with a tool that contacts flange. This

method will damage sealing edge and result in leakage and/or plug blow-out.

2. Flanged (trailing) edge must be below chamfered edge of bore to effectively seal the plugged bore. If core plug replacing tool has a depth seating surface, DO NOT seat the tool against a non-machined (casting) surface.

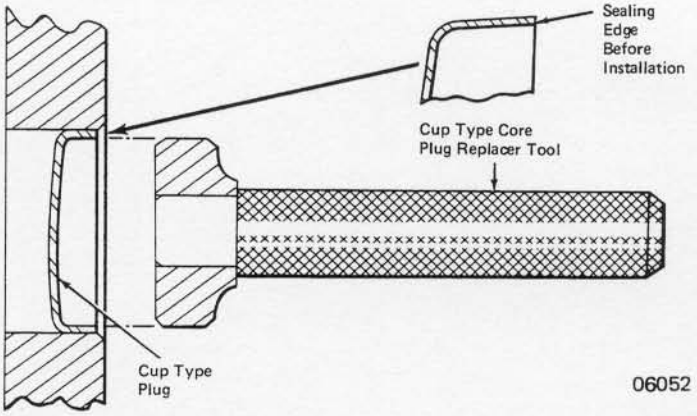
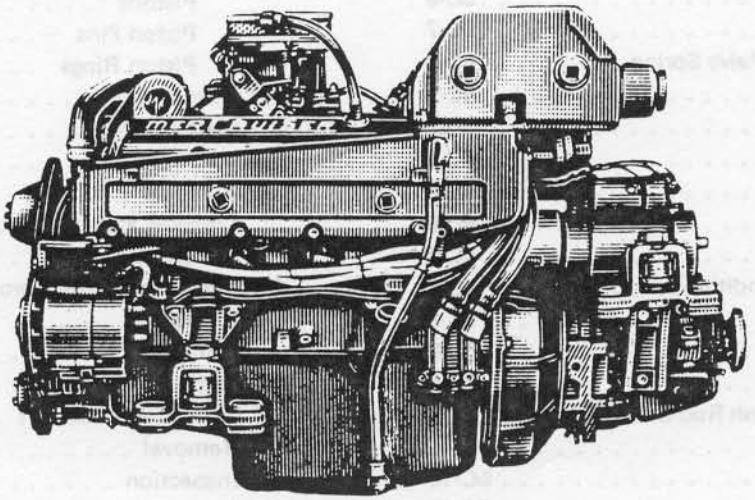


Figure 9. Core/Plug Replacement

SECTION 5 - ENGINE

mercruiser

PART C - ENGINE MECHANICAL, V-8 GM



MERCURY MARINE

A BRUNSWICK COMPANY

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ENGINE MECHANICAL - V-8 GM ENGINES

TOOLS

All "J-" (Special) Tools Listed in This Section May Be Purchased from:

Kent-Moore, Inc.
28635 Mound Road
Warren, Mich. 48089

GENERAL

NOTE: This section contains information for 305, 350 and 454 cubic inch displacement (CID) "GM" type MerCruiser Engines. While photos may not be exactly like all represented models, they are technically applicable as indicated.

Crankshaft has 5 main bearings and camshaft has 5 bearings.

Full pressure lubrication thru oil filter is furnished by gear-type oil pump. Distributor, driven by a helical gear on camshaft, drives the oil pump. Main oil gallery feeds oil thru drilled passages to camshaft and crankshaft to lubricate bearings. Valve lifter oil gallery feeds valve lifters, which, thru hollow push rods, feed individually mounted rocker arms.

Design of boat and particular repair procedure may require that engine be removed from boat. Engine should be placed on engine stand for major repairs.

ROCKER ARM COVER

REMOVAL

1. Remove rocker arm cover attaching screws.
2. Disconnect crankcase ventilation hoses.

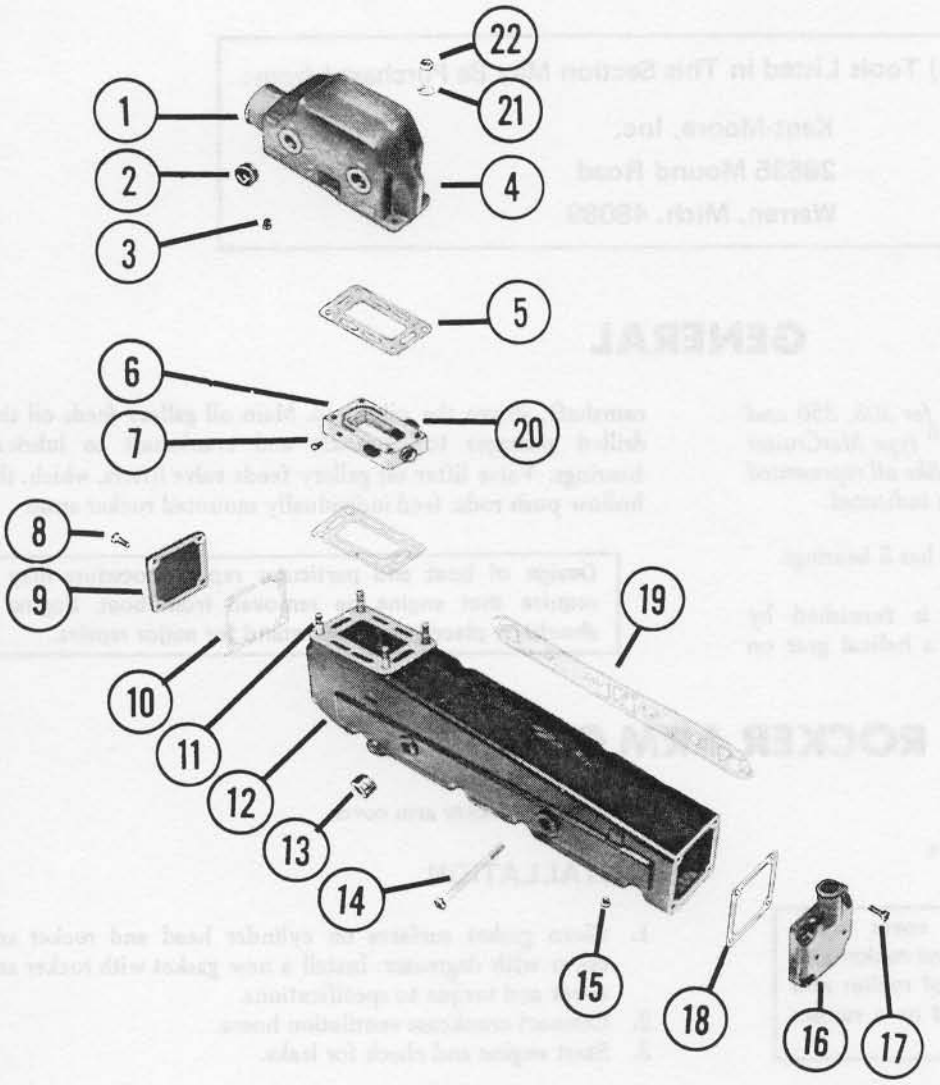
CAUTION: DO NOT pry rocker arm cover loose. Gaskets, which adhere to cylinder head and rocker arm cover, may be sheared by bumping end of rocker arm cover from the rear with palm of hand or a rubber mallet.

3. Remove rocker arm cover.

INSTALLATION

1. Clean gasket surfaces on cylinder head and rocker arm cover with degreaser. Install a new gasket with rocker arm cover and torque to specifications.
2. Connect crankcase ventilation hoses.
3. Start engine and check for leaks.

EXHAUST MANIFOLDS



1 - Tube
2 - Pipe Plug
3 - Drain Plug
4 - Exhaust Elbow
5 - Gasket
6 - Water Distribution Housing
7 - Drain Plug
8 - Screw
9 - End Cap
10 - Gasket
11 - Stud
12 - Exhaust Manifold
13 - Pipe Plug
14 - Belt
15 - Drain Plug
16 - End Cap
17 - Screw
18 - Gasket
19 - Gasket
20 - Sleeve
21 - Lockwasher
22 - Nut

Figure 1. Exhaust Manifold Assembly

REMOVAL

1. Left (port) manifold
   a. Drain engine cooling system.
   b. Remove exhaust tube and water hoses from left manifold.
   c. Remove bolts which secure left exhaust manifold to cylinder head.
2. Right (starboard) manifold
   a. Drain engine cooling system.
   b. Remove exhaust tube and water hoses from right manifold.
   c. Disconnect fuel lines from water separating fuel filter and remove fuel filter assembly.
   d. Remove bolts which secure right exhaust manifold to cylinder head.

CLEANING and INSPECTION

1. Clean gasket material from all mating surfaces and wash parts in solvent.
2. Check manifold for cracks and replace if cracked.
3. Inspect all parts carefully. Machined surfaces must be clean and free of all marks or scratches, or water or/and exhaust leaks may result.
4. Check water passages for sand, silt or other foreign material.
5. If further inspection is desired, pipe plugs may be removed from exhaust manifold and exhaust elbow.

INSTALLATION

1. Using new gaskets, install exhaust manifold to cylinder head. Torque bolts to specifications.

   NOTE: For right manifold installation, install dipstick tube support bracket with proper manifold bolt.

2. Install exhaust tubes and water hoses.
3. On right manifold installation, install water separating fuel filter and connect fuel lines.
4. Run engine and check for leaks.

INTAKE MANIFOLD

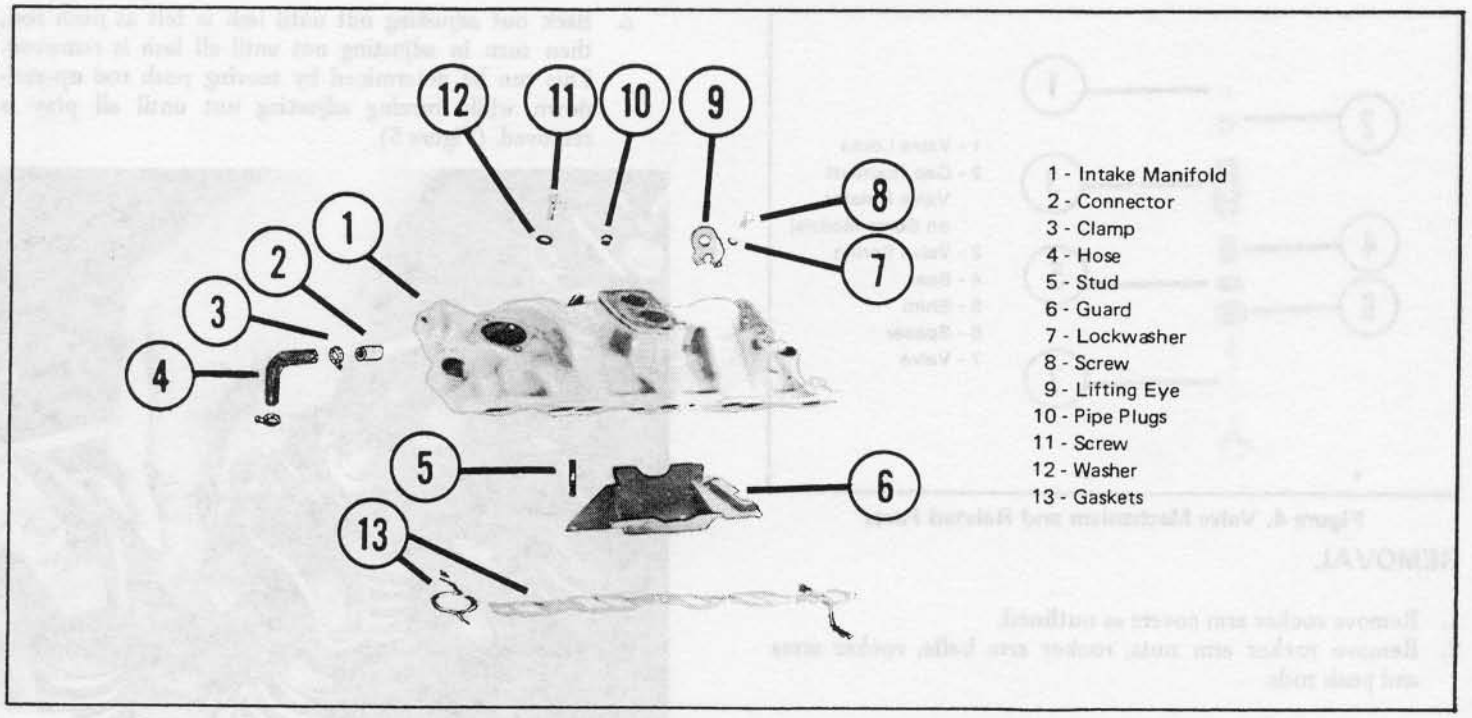


Figure 2. Intake Manifold Assembly and Related Parts

REMOVAL

1. Drain engine cooling system.
2. Disconnect crankcase ventilating hoses and water hoses.
3. Disconnect carburetor linkage and fuel line.
4. Disconnect distributor to switch box wires and distributor ground wire.
5. Remove distributor cap and mark rotor position with chalk. Also mark distributor position in intake manifold, then remove distributor.
6. Disconnect wire from water temperature sending unit.
7. Remove manifold attaching bolts, then remove manifold and carburetor as an assembly.

NOTE: If manifold is to be replaced, transfer carburetor and other related parts to new manifold.

CLEANING and INSPECTION

1. Clean gasket material from all mating surfaces.

CAUTION: When cleaning cylinder head mating surface, do not allow gasket material to enter engine crankcase.

2. Inspect manifold for cracks or scratches. Machined surfaces must be clean and free of all marks, or deep scratches or leaks may result.
3. Check intake passages for varnish buildup or other foreign material. Clean as necessary.

INSTALLATION

1. Install manifold gaskets on cylinder block and cylinder heads. Use Perfect Seal (C-92-34227) at water passages and where gaskets butt together.
2. Carefully install manifold assembly and torque bolts to specifications in sequence outlined in Figure 3 or 3A.

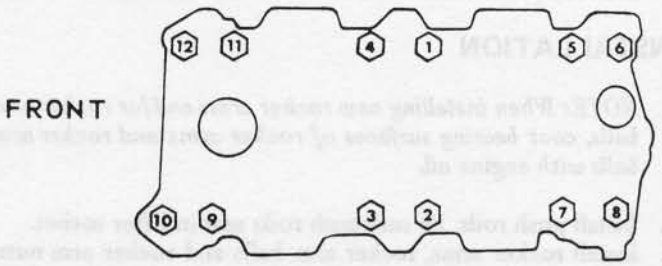


Figure 3. Intake Manifold Torque Sequence - 305 and 350 CID Models

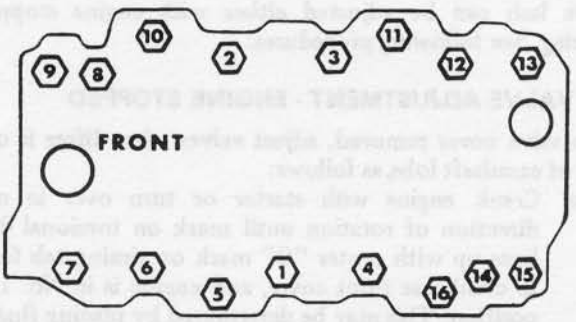


Figure 3A. Intake Manifold Torque Sequence - 454 CID Models

3. Install distributor, positioning distributor housing and rotor to aline with chalk marks, then install distributor cap.
4. Connect distributor wires to switch box and ground.
5. Connect fuel line and carburetor linkage.
6. Connect water temperature sending unit wire.
7. Connect crankcase ventilating hoses and water hoses.
8. Start engine; adjust ignition timing and carburetor idle speed and mixture. Check for leaks.

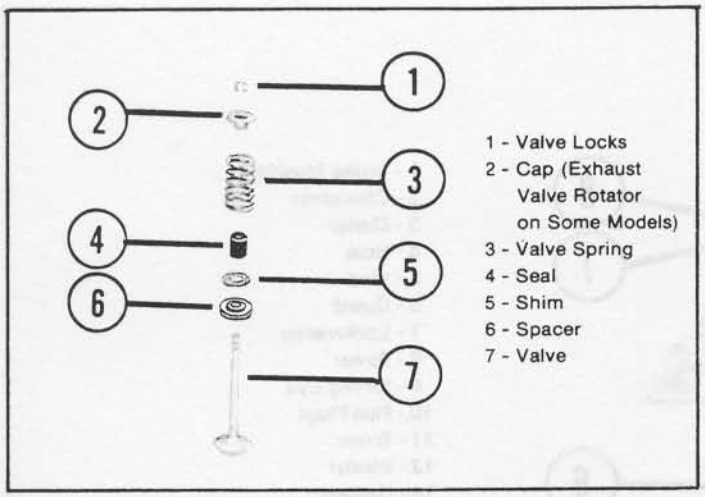


Figure 4. Valve Mechanism and Related Parts

REMOVAL

1. Remove rocker arm covers as outlined.
2. Remove rocker arm nuts, rocker arm balls, rocker arms and push rods.

NOTE: Place rocker arms, rocker arm balls and push rods in a rack for reinstallation in the same locations.

INSTALLATION

NOTE: When installing new rocker arms and/or rocker arm balls, coat bearing surfaces of rocker arms and rocker arm balls with engine oil.

1. Install push rods. Be sure push rods seat in lifter socket.
2. Install rocker arms, rocker arm balls and rocker arm nuts. Tighten rocker arm nuts until all lash is eliminated.

ADJUSTMENT

Valve lash can be adjusted either with engine stopped or running. See following procedures.

1. VALVE ADJUSTMENT - ENGINE STOPPED

With valve cover removed, adjust valves when lifter is on low part of camshaft lobe, as follows:

a. Crank engine with starter or turn over in normal direction of rotation until mark on torsional damper lines up with center "O" mark on timing tab fastened to crankcase front cover, and engine is in No. 1 firing position. This may be determined by placing fingers on No. 1 valve as mark on damper comes near "O" mark on timing mark. If valves move as mark comes up to timing tab, engine is in No. 6 firing position and should be turned over one more time to reach No. 1 position.

b. With engine in No. 1 firing position as determined above, the following valves may be adjusted.

Left Hand (Standard) Rotation Engines

Exhaust - 1-3-4-8
Intake - 1-2-5-7

Right Hand (Opposite) Rotation Engines

Exhaust - 1-2-5-7
Intake - 1-3-4-8

c. Back out adjusting nut until lash is felt at push rod, then turn in adjusting nut until all lash is removed. This can be determined by moving push rod up-and-down while turning adjusting nut until all play is removed. (Figure 5)

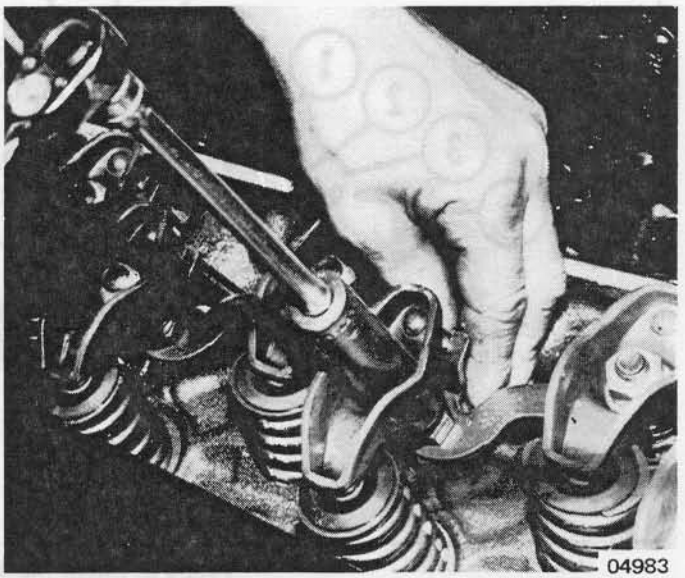


Figure 5. Valve Adjustment - Engine Stopped

Hydraulic lifters now can be adjusted by tightening adjustment nut an additional ¾-turn to place plunger in center of its travel. No other adjustment is required.

d. Crank engine one revolution until pointer "O" mark and torsional damper mark are again in alignment. This is No. 6 firing position. With engine in this position, the following valves may be adjusted as previously outlined.

Left Hand (Standard) Rotation Engines

Exhaust - 2-5-6-7
Intake - 3-4-6-8

Right Hand (Opposite) Rotation Engines

Exhaust - 3-4-6-8
Intake - 2-5-6-7

e. Install rocker arm covers as outlined.
f. Adjust carburetor idle speed and mixture.

2. VALVE ADJUSTMENT - ENGINE RUNNING

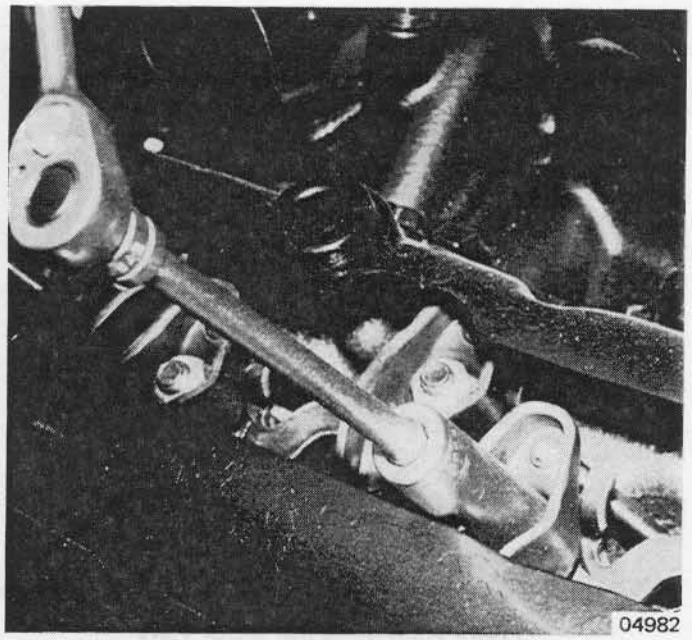
Following procedure is performed with engine running:

a. After engine has been rechecked for normal operating temperature, remove valve covers and install a re-worked valve cover (cut top out of a used valve cover) and gasket on cylinder heads to prevent oil from running out. (Figure 6)

b. With engine running at idle, back valve rocker arm nuts off (one at a time) until valve rocker arm starts to clatter.

c. Turn rocker arm nut down until clatter just stops. This is zero lash position.

d. Turn nut down ¼ additional turn and pause 10 seconds until engine runs smoothly. Repeat additional ¼ turns, pausing 10 seconds each time, until nut has been turned down ¾-turn from the zero lash position.



NOTE: This ¾-turn preload adjustment must be done slowly to allow lifter to adjust itself, thus preventing possibility of interference between inlet valve head and top of piston which might result in internal damage and/or bent push rods.

e. Repeat Steps b-c-d to adjust other valves. Remove reworked valve covers and install new gaskets and covers.
f. Adjust carburetor idle speed and mixture.

Figure 6. Valve Adjustment - Engine Running

HYDRAULIC VALVE LIFTERS

Hydraulic valve lifters require little attention. Lifters are extremely simple in design, readjustments are not necessary and servicing requires only that care and cleanliness be exercised in the handling of parts. Parts identification is shown in Figure 7.

LOCATING NOISY LIFTERS

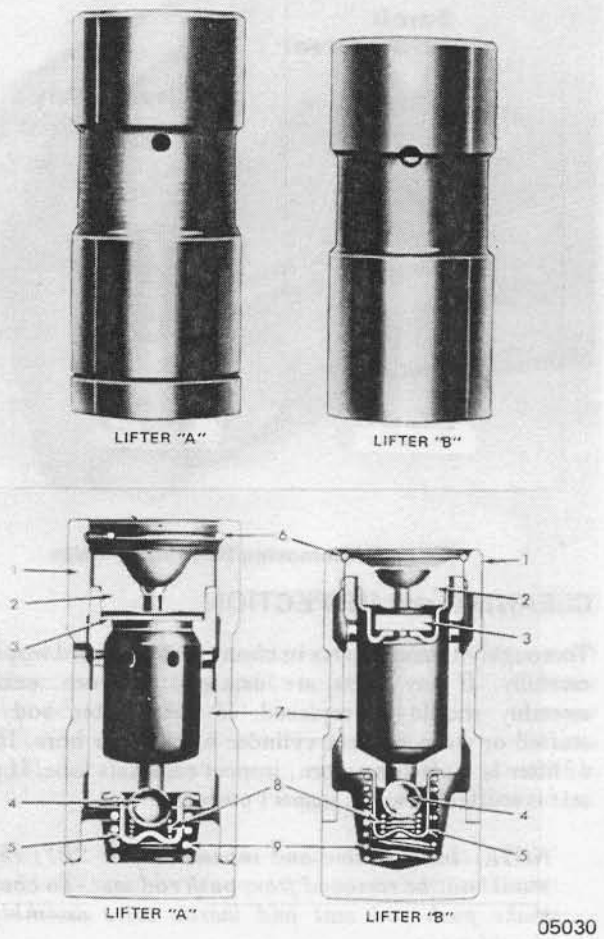
Locate a noisy valve lifter by using a piece of garden hose approximately 4 ft. (1.2m) in length. Place one end of hose near end of each intake and exhaust valve, with other end of hose to the ear. In this manner, sound is localized, making it easy to determine which lifter is at fault.

Another method is to place a finger on face of valve spring retainer. If lifter is not functioning properly, a distinct shock will be felt when valve returns to its seat.

General types of valve lifter noise are as follows:

1. Hard rapping noise -- Usually caused by plunger becoming tight in bore of lifter body so that return spring cannot push plunger back up to working position. Probable causes are:
   a. Excessive varnish or carbon deposit, causing abnormal stickiness.
   b. Galling or "pick-up" between plunger and bore of lifter body, usually caused by an abrasive piece of dirt or metal wedged between plunger and lifter body.
2. Moderate rapping noise -- Probable causes are:
   a. Excessively high leakdown rate.
   b. Leaky check valve seat.
   c. Improper adjustment.
3. General noise throughout valve train – This will, in most cases, be a definite indication of insufficient oil supply or improper adjustment.
4. Intermittent clicking -- Probable causes are:
   a. A microscopic piece of dirt momentarily caught between ball seat and check valve ball.
   b. In rare cases, ball itself may be out-of-round or have a flat spot.
   c. Improper adjustment.

In most cases, where noise exists in one or more lifters, all lifter units should be removed, disassembled, cleaned in



1 - Lifter Body
2 - Push Rod Seat
3 - Metering Valve (Lifter A) Inertia Valve (Lifter B)
4 - Check Ball
5 - Check Ball Retainer
6 - Push Rod Seat Retainer
7 - Plunger
8 - Check Ball Spring
9 - Plunger Spring

Figure 7. Hydraulic Valve Lifters

solvent, reassembled and reinstalled in engine. If dirt, corrosion, carbon, etc, is shown to exist in one unit, it more likely exists in all the units, thus it would only be a matter of time before all lifters caused trouble.

REMOVAL

1. Remove intake manifold as outlined.
2. Remove valve mechanism as outlined.
3. Remove valve lifters.

NOTE: Place valve lifters in a rack so that they may be reinstalled in same location.

DISASSEMBLY

1. Hold plunger down with a push rod and remove push rod seat retainer with blade of small screwdriver.
2. Remove push rod seat and metering valve (lifter "A") or push rod seat and inertia valve assembly (lifter "B"). (Figure 7)
3. Remove plunger, ball check valve assembly and plunger spring.
4. Remove ball check valve and spring by prying ball retainer loose from plunger with blade of a small screwdriver. (Figure 8)

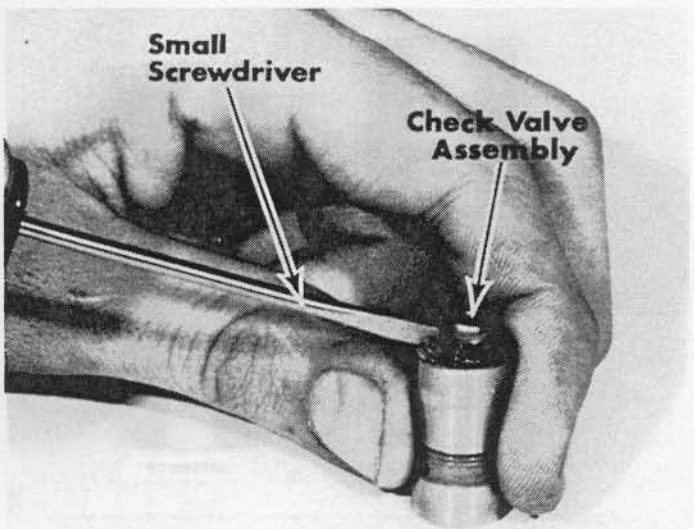


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Figure 8. Removing Ball Check Valve

CLEANING and INSPECTION

Thoroughly clean all parts in cleaning solvent and inspect them carefully. If any parts are damaged or worn, entire lifter assembly should be replaced. If outer lifter body wall is scuffed or worn, inspect cylinder block lifter bore. If bottom of lifter is scuffed or worn, inspect camshaft lobe. If push rod seat is scuffed or worn, inspect push rod.

NOTE: Inertia valve and retainer (lifter "B") (Figure 7) should not be removed from push rod seat. To check valve, shake push rod seat and inertia valve assembly. Valve should move.

REASSEMBLY

1. Place check ball on small hole in bottom of plunger.
2. Insert check ball spring on seat in ball retainer and place retainer over ball so that spring rests on ball. Carefully press retainer into position in plunger with blade of a small screwdriver. (Figure 9)
3. Place plunger spring over ball retainer and slide lifter body over spring and plunger, being careful to line up the oil feed holes on lifter body plunger.
4. Fill assembly with oil, then insert end of a 1/8" drift pin into plunger and press down. At this point, oil holes in lifter body and plunger assembly will be aligned. (Figure 10)

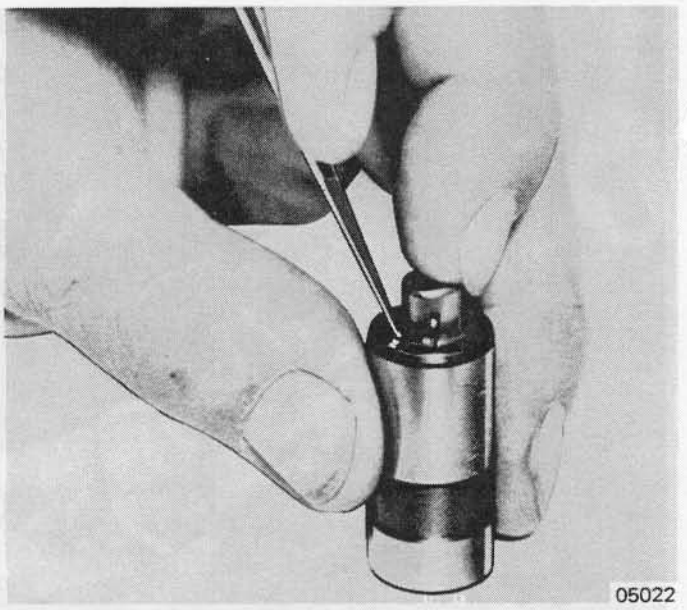

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Figure 9. Installing Ball Check Valve

CAUTION: Do not attempt to force or pump the plunger.

5. Insert a 1/16" drift pin thru both oil holes to hold plunger down against lifter spring tension. (Figure 10)

NOTE: On lifter "B" (Figure 7),drift pin must not extend inside plunger.

6. Remove 1/8" drift pin and refill assembly with oil.

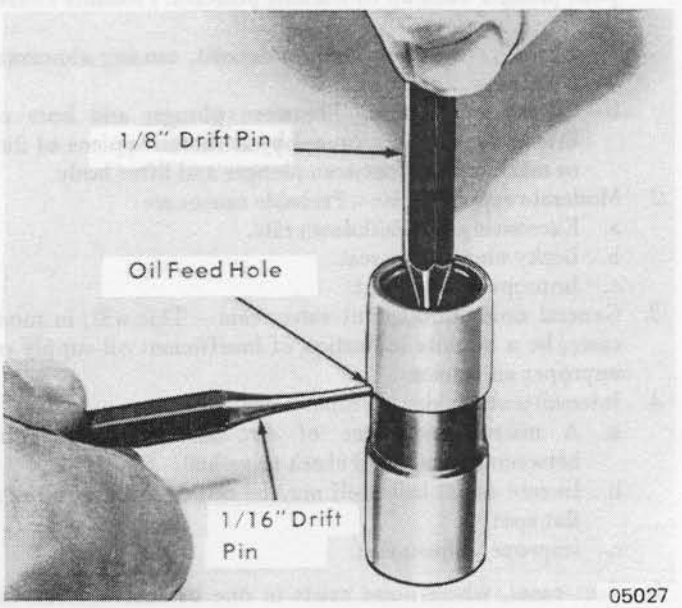

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Figure 10. Assembling Hydraulic Lifters

7. Install metering valve and push rod seat (lifter "A") or push rod seat and inertia valve assembly (lifter "B"). (Figure 7)
8. Install push rod seat retainer, press down in push rod seat and remove 1/16" drift pin from oil holes. Lifter now is completely assembled, filled with oil and ready for installation.

NOTE: Before installing lifters, coat bottom of lifter with engine oil.

INSTALLATION

NOTE: Whenever valve lifters are being installed, coat bottom of valve lifters with engine oil.

1. Install valve lifters.
2. Install intake manifold as outlined.
3. Install and adjust valve mechanism as outlined.

Two types of hydraulic lifters are used. Both types operate on the same principle and are serviced basically in the same manner. Complete lifter assemblies are interchangeable, but parts from one lifter are not interchangeable with another. Both lifters are easily identified by outside configuration of lifter body. Identify them as lifter "A" and lifter "B". (Figure 7)

VALVE STEM OIL SEAL and/or VALVE SPRING

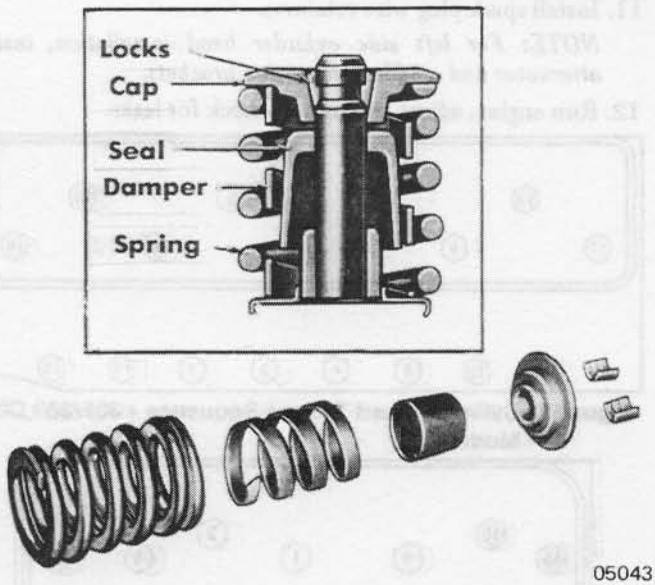

Figure 11. Valve Assembly Related Parts

REMOVAL

1. Remove rocker arm cover as outlined.
2. Remove spark plug, rocker arm and push rod on cylinder(s) to be serviced.
3. Apply compressed air to spark plug hole to hold valves in place.

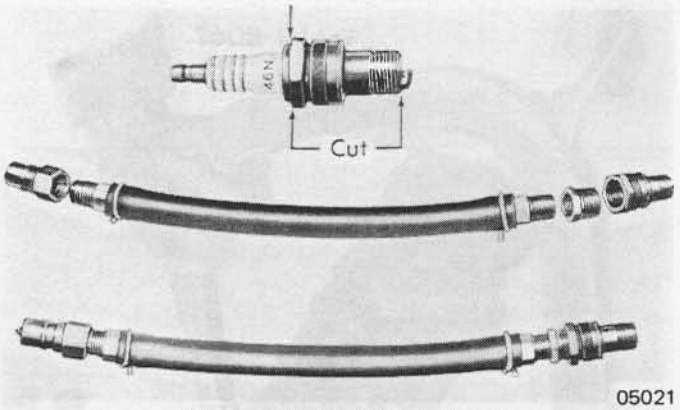

Figure 12. Air Adaptor Tool

NOTE: A tool to apply air to the cylinder is available thru local jobbers, or spark plug may be used. (Be sure to use correct seat-type plug.) Chisel spark plug as shown, then drive porcelain out of plug by tapping center electrode against a hard block. Using a 3/8" pipe tap, cut threads in remaining portion of spark plug and assemble as shown. (Figure 12)

4. Compress valve spring with J-5892 tool to remove valve locks, valve cap (or rotator) and valve spring and damper. (Figure 13)
5. Remove valve stem oil seal.

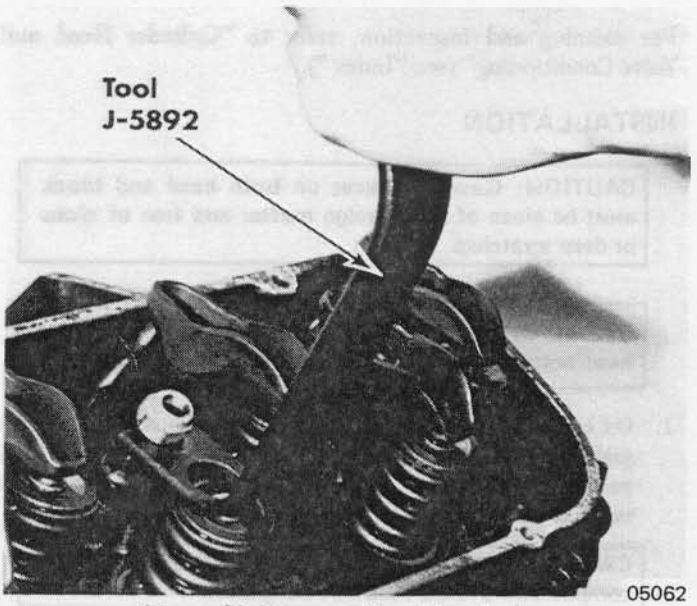

Figure 13. Compressing Valve Spring

REASSEMBLY

305/350 CID Models

1. Set valve spring, damper, valve shield and cap in place. Compress spring with Tool J-5892 and install oil seal into lower groove of valve stem.

   NOTE: A light film of oil will help prevent twisting of the seal.
2. Install valve locks and release pressure of tool, being sure that locks are in place. Grease may be used to help hold locks while removing pressure from tool.

454 CID Models

1. Install new valve stem oil seal (coated with oil) in position over valve guide.
2. Set spacer, valve spring and damper and valve cap in place.
3. Compress spring with J-5892 tool and install valve locks. Then release compressor tool, making sure that locks seat properly in groove of valve stem.

   NOTE: Grease may be used to hold locks in place while releasing compressor tool.
4. Install spark plug, using a new gasket, and torque to specifications.
5. Install and adjust valve mechanism as outlined.

CYLINDER HEAD

REMOVAL

1. Drain engine cooling system.
2. Remove exhaust manifolds as outlined.
3. Remove intake manifold as described.
4. Remove valve mechanism as outlined.

NOTE: For left side cylinder head, remove alternator and oil filter mounting brackets.

5. Remove spark plugs.
6. Remove spark plug wire retainers from cylinder head.
7. Remove cylinder head bolts, cylinder head and gasket. Place cylinder head on 2 blocks of wood to prevent damage.

CLEANING and INSPECTION

For cleaning and inspection, refer to "Cylinder Head and Valve Conditioning" (see "Index").

INSTALLATION

CAUTION: Gasket surfaces on both head and block must be clean of any foreign matter and free of nicks or deep scratches.

Cylinder bolt threads in block and threads on cylinder head bolts must be clean. (Dirt will affect bolt torque.)

1. On engines using a STEEL gasket, coat both sides of new gasket with Perfect Seal (C-92-34227). Spread sealer thin and even. A paint roller makes a good applicator. Too much sealer may hold gasket away from head or block.

CAUTION: Use no sealer on engines which have a composition STEEL ASBESTOS gasket.

2. Place gasket in position over dowel pins.
3. Carefully guide cylinder head into place over dowel pins and gasket.
4. Coat threads of cylinder head bolts with Perfect Seal and install bolts finger-tight.
5. Tighten each cylinder head bolt a little at a time in sequence shown in torque sequence chart until specified torque is reached. (Figure 1 or 1A)
6. Install exhaust manifolds as outlined.
7. Install intake manifold as described.
8. Install and adjust valve mechanism as outlined.
9. Install valve covers.
10. Install spark plugs. Torque spark plugs to specifications.
11. Install spark plug wire retainers.

NOTE: For left side cylinder head installation, install alternator and oil filter mounting brackets.

12. Run engine, adjust timing and check for leaks.

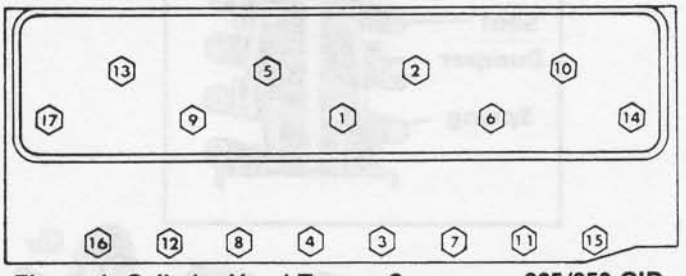

Figure 1. Cylinder Head Torque Sequence - 305/350 CID Models

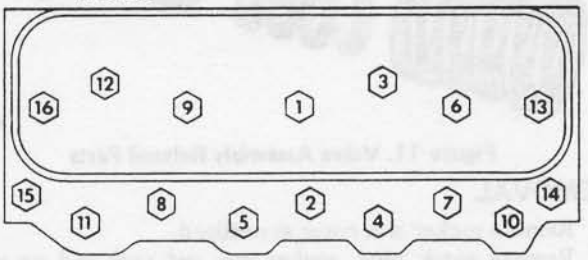

Figure 1A. Cylinder Head Torque Sequence - 454 CID Models

CYLINDER HEAD and VALVE CONDITIONING

DISASSEMBLY

1. With cylinder head removed, remove valve rocker arm nuts, balls and rocker arms (if not previously done).
2. Compress valve springs with J-8062 tool (Figure 2) and remove valve retainers. Release compressor tool and remove spring caps, and springs and spring damper, then remove oil seals and valve spring spacer.
3. Remove valves from cylinder head and place valves in a rack in their proper sequence for reassembly in their original positions.

CLEANING

1. Clean all carbon from combustion chambers and valve ports with J-8089 tool. (Figure 3)
2. Thoroughly clean valve guides with J-8101 tool. (Figure 4)
3. Clean all carbon and sludge from push rods, rocker arms and push rod guides.
4. Clean carbon from valves on a buffing wheel.
5. Clean carbon deposits and gasket material from cylinder head mating surfaces.

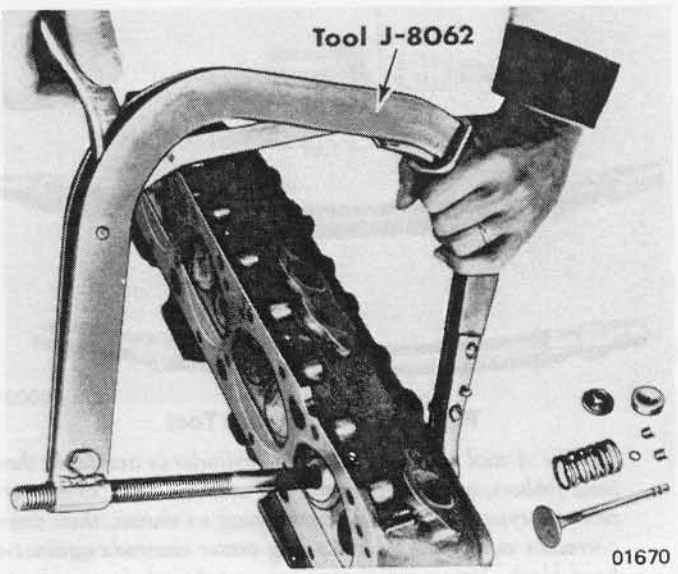

Figure 2. Compressing Valve Spring

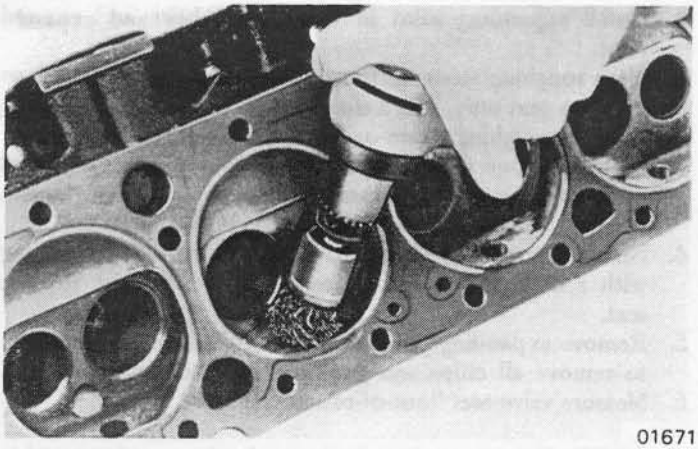

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Figure 3. Cleaning Combustion Chambers

INSPECTION

1. Inspect cylinder head for cracks in exhaust ports, combustion chambers and for external cracks to water chamber.
2. Inspect valves for burned heads, cracked faces or damaged stems.

   NOTE: Excessive valve stem to bore clearance will cause excessive oil consumption and possible valve breakage. Insufficient clearance will result in noisy and sticky functioning of valve and disturb engine smoothness.

3. Measure valve stem clearance (Figure 5) as follows: Clamp a dial indicator on one side of cylinder head rocker arm cover gasket rail, locating indicator so that movement of valve stem from side-to-side (crosswise to the head) will cause a direct movement of indicator stem. Indicator stem must contact side of valve stem just above valve guide. With valve head dropped about 1/16" (1.6mm) off valve seat, move valve stem from side-to-side, using light pressure to obtain a clearance reading. If clearance exceeds specifications, it will be necessary to ream valve guides for oversize valves, as outlined under "Valve Guide Bores" (see "Index").
4. Check valve spring tension with J-8056 spring tester. (Figure 6)

   NOTE: Springs should be compressed to specified height and checked against specification chart. Springs should be replaced if not within 10 lbs. of specified load (without dampers).

5. Inspect rocker arm studs for wear or damage. Inspect push rod guides for wear or damage.

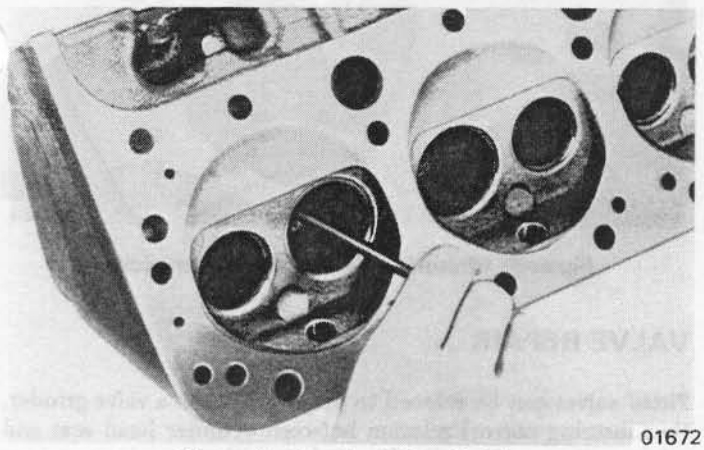

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Figure 4. Cleaning Valve Guides

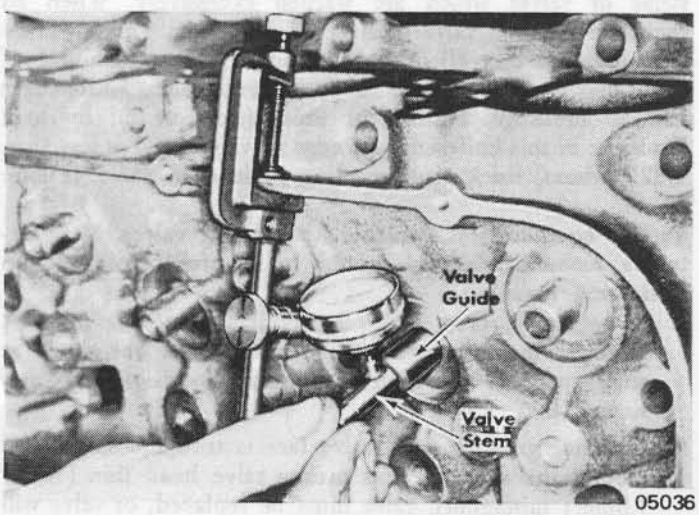

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Figure 5. Measuring Valve Stem Clearance

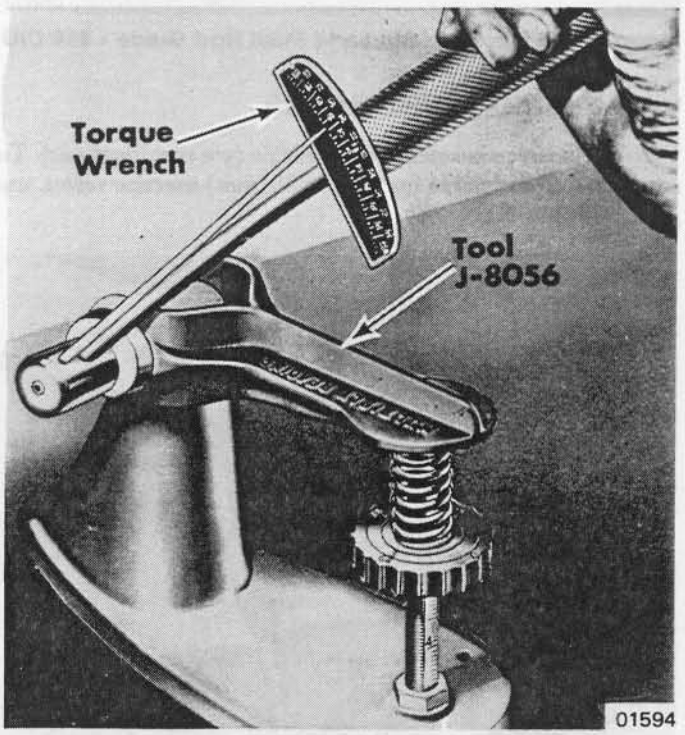

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Figure 6. Checking Valve Spring Tension

ROCKER ARM STUDS and PUSH ROD GUIDES - REPAIRS

305/350 CID Models

1. Rocker arm studs, which are replaced because of wear or looseness, should be replaced with oversize studs.
2. Use Tool J-5802-1 to remove old stud by placing tool, flat washer and nut over stud, then turning nut.
3. Ream stud hole, whenever installing an oversize stud, using appropriate reaming tool.
4. Install new stud with Tool J-6880 or similar stud installing tool made for press-in type studs. Follow instructions with tool.

454 CID Models

NOTE: Coat threads on cylinder head end of rocker arm studs with sealer before assembling to cylinder head.

Push rod guides are attached to cylinder head by rocker arm studs. (Figure 7) Replace if worn and torque rocker arm studs to specifications.

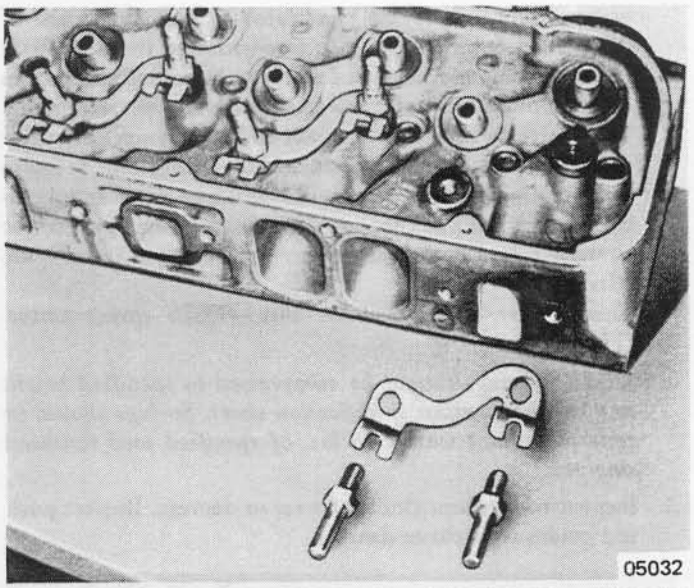


Figure 7. Rocker Arm Stud and Push Rod Guide - 454 CID Models

VALVE GUIDE BORE REPAIR

Valves with oversize stems are available (see specifications). To ream valve guide bores for .015" (.381mm) oversize valves, use J-7910-5 tool. (Figure 8)

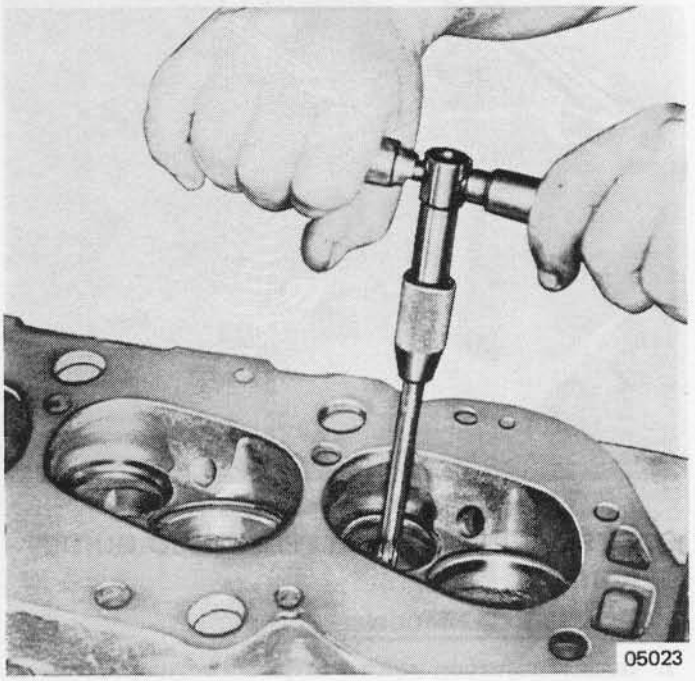


Figure 8. Reaming Valve Guide

VALVE SEAT REPAIR

Valve seat reconditioning is very important, since seating of valves must be perfect for engine to deliver maximum power and performance.

Another important factor is valve head cooling. Good contact between each valve and its seat in head is important to insure that heat in valve head will be properly dispersed.

Several different types of equipment are available for reseating valve seats. Equipment manufacturer's recommendations should be followed carefully to attain proper results.

Regardless of type of equipment, however, it is essential that valve guide bores be free from carbon or dirt to insure proper centering of pilot in valve guide.

1. Install expanding pilot in valve guide bore and expand pilot.
2. Place roughing stone or forming stone over pilot and clean up valve seat only. Use a stone that is cut to specifications.
3. Remove roughing stone or forming stone from pilot, place finishing stone (cut to specifications) over pilot and cut just enough metal from seat to provide a smooth finish. Refer to "Specifications" Section 8 and Figure 10.
4. Narrow down valve seats to specified width by grinding with a 30° stone to lower seat and a 60° stone to raise seat.
5. Remove expanding pilot and clean cylinder head carefully to remove all chips and grindings from above operations.
6. Measure valve seat "out-of-round". (Figure 9)

NOTE: Valve seats should be perfectly round to within .002" (.051mm) total indicator reading.

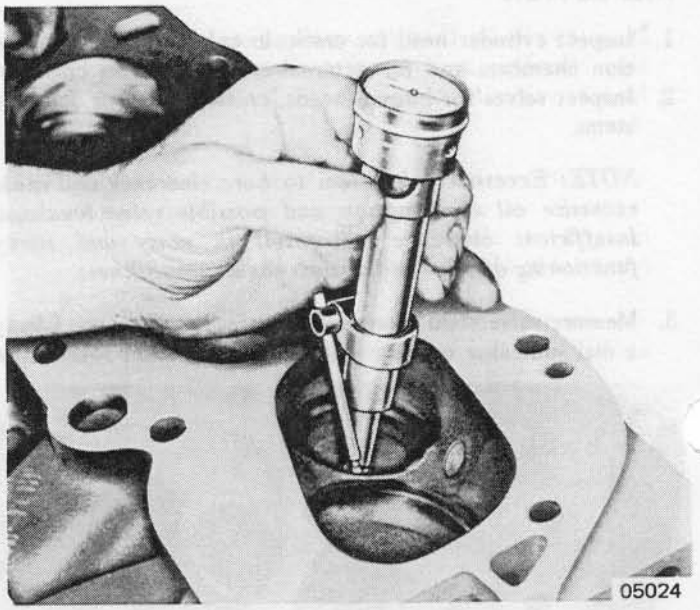


Figure 9. Measuring Valve Seat Concentricity

VALVE REPAIR

Pitted valves can be refaced to proper angle on a valve grinder, thus insuring correct relation between cylinder head seat and valve mating surface. Replace valves with excessive wear on stems or valves which are warped excessively. When an excessively-warped valve head is refaced, a knife edge will be ground on part or all of the valve head, due to amount of metal that must be removed to completely reface. Knife edges lead to breakage, burning or pre-ignition caused by heat localizing in this knife edge. If edge of valve head is less than 1/32" (.8mm) thick after grinding, replace the valve. (Figure 11)

Various equipment is available for refacing valves. Manufacturer's recommendations should be carefully followed to attain proper results.

1. If necessary, dress the valve refacing machine grinding wheel to make sure it is smooth and true. Set chuck at angle specified for valve. Refer to "Specifications" and Figure 10.
2. Continue grinding until valve face is true and smooth all around the valve. If this makes valve head thin (1/32" [.8mm] minimum), valve must be replaced, or valve will overheat and burn. (Figure 11)

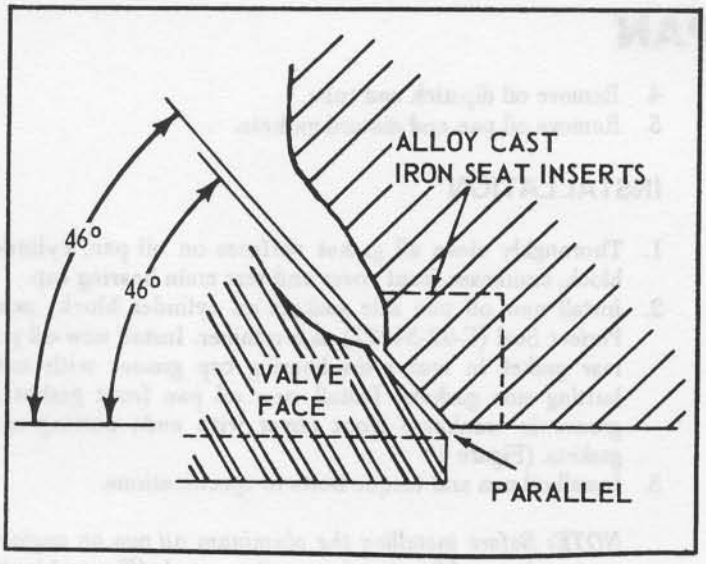


Figure 10. Relation of Valve and Seat Angles

3. Remove valve from chuck and place stem in "V" block. Feed valve squarely against grinding wheel to grind any pit from rocker arm end of stem.

   NOTE: Only extreme end of valve stem is hardened to resist wear. Do not grind end of stem excessively.

4. After cleaning valve face and cylinder head valve seat of grinding particles, make pencil marks about ¼" (6.4mm) across the valve face, place valve in cylinder head and give valve ½-turn in each direction while exerting firm pressure on head of valve.
5. Remove valve and check face carefully. If all pencil marks have not been removed at point of contact with valve seat, repeat refacing operation and again recheck for proper seating.

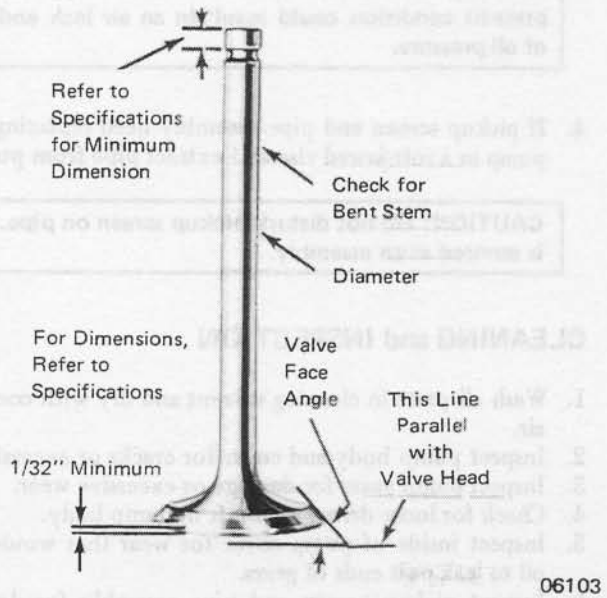


Figure 11. Critical Valve Dimensions

REASSEMBLY

1. Insert valve in proper port.
2. Install valve spring spacer on valve spring seat, then install a new valve stem oil seal over valve and valve guide.
3. Set valve spring (with damper) and valve cap in place. (Figure 12)
4. Compress spring with tool J-8062.
5. Install valve locks and release compressor tool, making sure that locks seat properly in groove of valve stem.

   NOTE: Grease may be used to hold locks in place while releasing compressor tool.

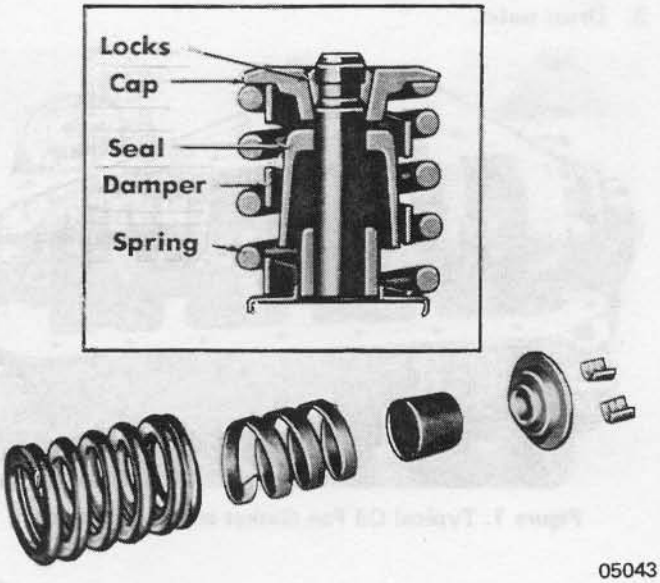


Figure 12. Valve Spring Installation

6. Install remaining valves.
7. Check installed height of the valve springs with a narrow, thin scale. A cutaway scale will help. (Figure 13) Measure from top of spacer (spring seat) to top of valve spring. (Figure 14) If this exceeds specified height, install a valve spring seat shim approximately 1/16" (1.6mm) thick. At no time should spring be shimmed to give an installed height under minimum specified.

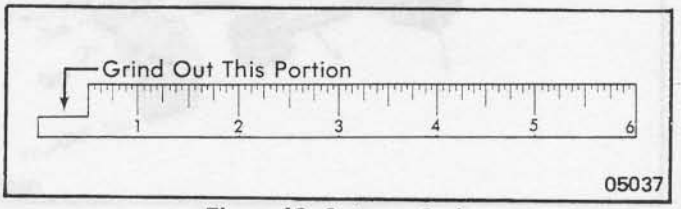


Figure 13. Cutaway Scale

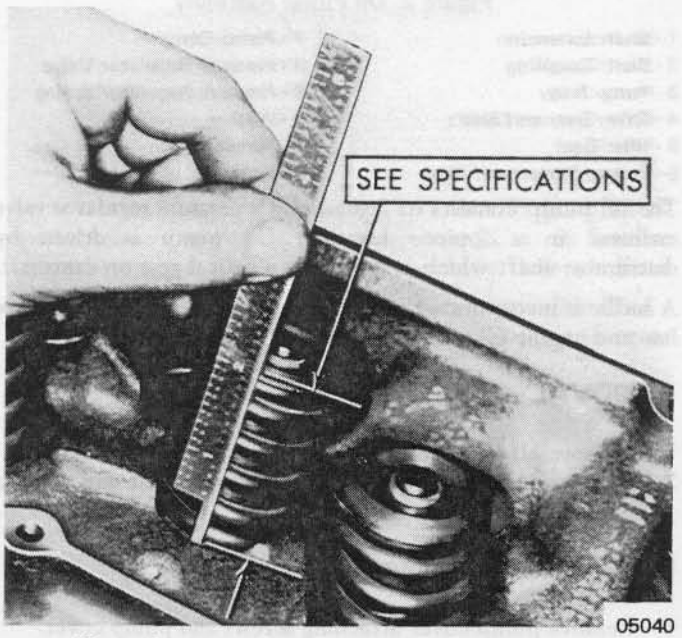


Figure 14. Measuring Valve Spring Installed Height

OIL PAN

REMOVAL

1. Remove engine from boat.
2. Drain crankcase oil.
3. Drain water.

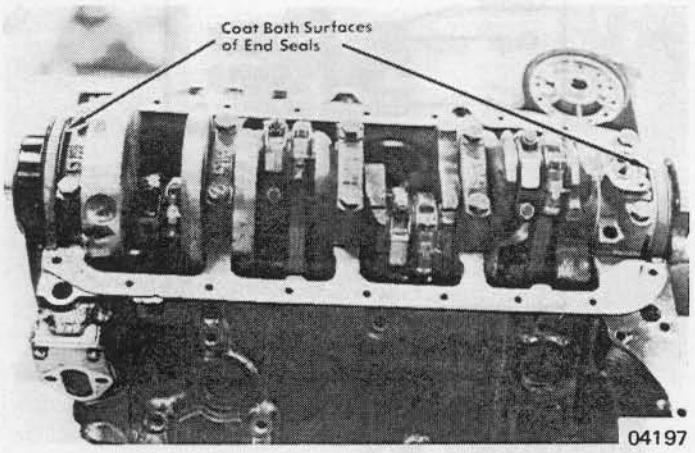


Figure 1. Typical Oil Pan Gasket and Seal Locations

4. Remove oil dipstick and tube.
5. Remove oil pan and discard gaskets.

INSTALLATION

1. Thoroughly clean all gasket surfaces on oil pan, cylinder block, crankcase front cover and rear main bearing cap.
2. Install new oil pan side gaskets on cylinder block, using Perfect Seal (C-92-34227) as a retainer. Install new oil pan rear gasket in rear main bearing cap groove with ends butting side gaskets. Install new oil pan front gasket in groove in crankcase front cover with ends butting side gaskets. (Figure 1)
3. Install oil pan and torque bolts to specifications.

NOTE: Before installing the aluminum oil pan on engines, coat surfaces of front and rear oil pan seals (Figure 1) with Sealant (C-92-52238).

4. Install oil dipstick tube and dipstick.
5. Install engine in boat. Fill engine with oil, start engine and check for leaks.

OIL PUMP

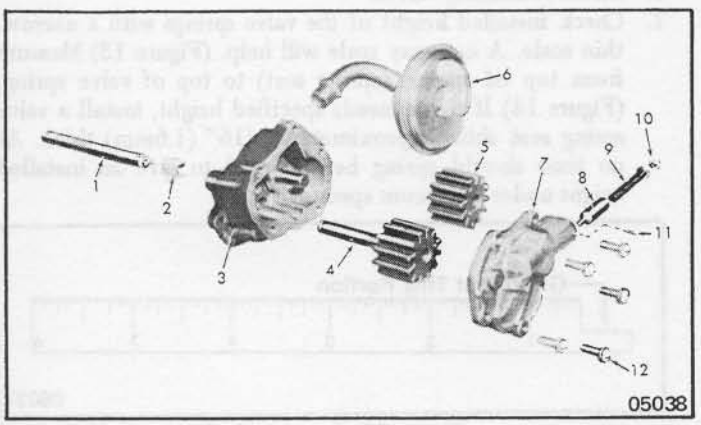


Figure 2. Oil Pump Assembly

1 - Shaft Extension
2 - Shaft Coupling
3 - Pump Body
4 - Drive Gear and Shaft
5 - Idler Gear
6 - Pickup Screen and Pipe
7 - Pump Cover
8 - Pressure Regulator Valve
9 - Pressure Regulator Spring
10 - Washer
11 - Retaining Pin
12 - Screws

The oil pump consists of 2 gears and a pressure regulator valve enclosed in a 2-piece housing. Oil pump is driven by distributor shaft which is driven by a helical gear on camshaft.

A baffle is incorporated on pickup screen to eliminate pressure loss and engine oil pump tubes are bent at special angles.

REMOVAL

1. Remove oil pan as outlined.
2. Remove pump to rear main bearing cap bolt and remove pump and extension shaft.

DISASSEMBLY (Figure 2)

1. Remove pump cover attaching screws and pump cover.

NOTE: Mark gear teeth for reassembly with same teeth indexing.

2. Remove idler gear, drive gear and shaft from pump body.
3. Remove pressure regulator valve retaining pin, pressure regulator valve and related parts.

CAUTION: DO NOT remove pickup screen and pipe assembly, unless replacement is necessary. Loss of press-fit condition could result in an air leak and loss of oil pressure.

4. If pickup screen and pipe assembly need replacing, mount pump in a soft-jawed vise and extract pipe from pump.

CAUTION: Do not disturb pickup screen on pipe. This is serviced as an assembly.

CLEANING and INSPECTION

1. Wash all parts in cleaning solvent and dry with compressed air.
2. Inspect pump body and cover for cracks or excessive wear.
3. Inspect pump gears for damage or excessive wear.
4. Check for loose drive gear shaft in pump body.
5. Inspect inside of pump cover for wear that would permit oil to leak past ends of gears.
6. Inspect pickup screen and pipe assembly for damage to screen or pipe.
7. Check pressure regulator valve for fit.

NOTE: Pump gears and body are not serviced separately. If pump gears or body are damaged or worn, replacement of entire oil pump assembly is necessary.

REASSEMBLY

CAUTION: Be careful of twisting, shearing or collapsing pipe while installing in pump. Pickup screen must be parallel to bottom of oil pan when oil pump is installed.

1. If pickup screen and pipe assembly was removed, it should be replaced with a new part. Loss of press-fit condition could result in an air leak and loss of oil pressure. Mount pump in a soft-jawed vise, apply sealer to end of pipe and, using tool J-8369, tap pipe in place with a plastic hammer. (Figure 3)

NOTE: Oil internal parts liberally before installation.

Figure 3. Installing Screen

2. Install pressure regulator valve and related parts.
3. Install drive gear and shaft in pump body.
4. Install idler gear in pump body with smooth side of gear toward pump cover opening. Align marks made in disassembly.

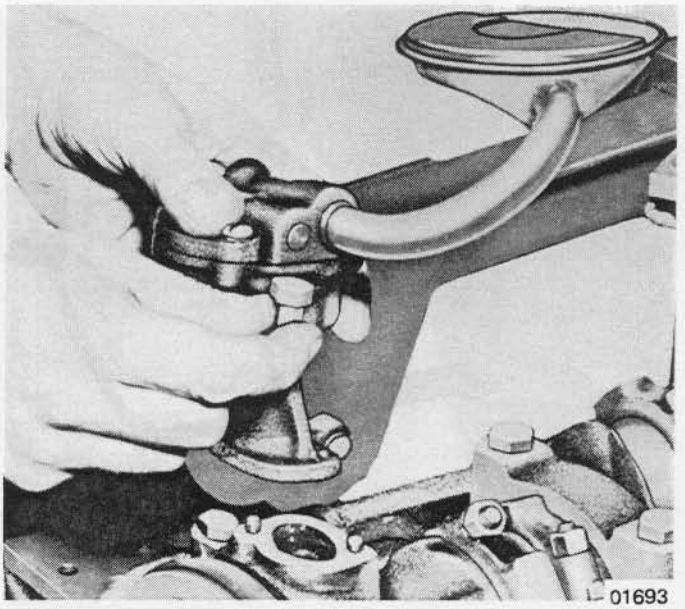


Figure 4. Oil Pump Removal and Installation

5. Install pump cover and torque attaching screws to specifications.
6. Turn drive shaft by hand to check for smooth operation.

INSTALLATION

1. Assemble pump and extension shaft to rear main bearing cap, aligning slot on top end of extension shaft with drive tang on lower end of distributor drive shaft.
2. Install pump to rear main bearing cap and torque to specifications. (Figure 4)

NOTE: Oil pump screen is installed with bottom edge parallel to oil pan rails.

3. Install oil pan as outlined.

TORSIONAL DAMPER

REMOVAL

1. Remove drive belts.
2. Remove drive pulley, then remove damper retaining bolt.

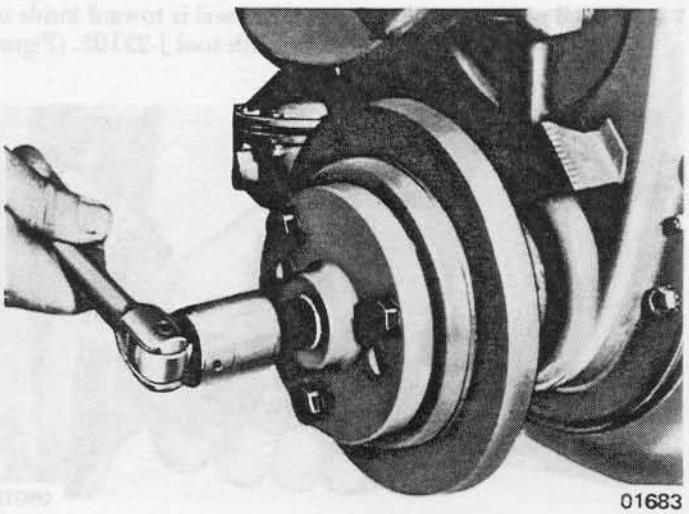


Figure 5. Removing Torsional Damper

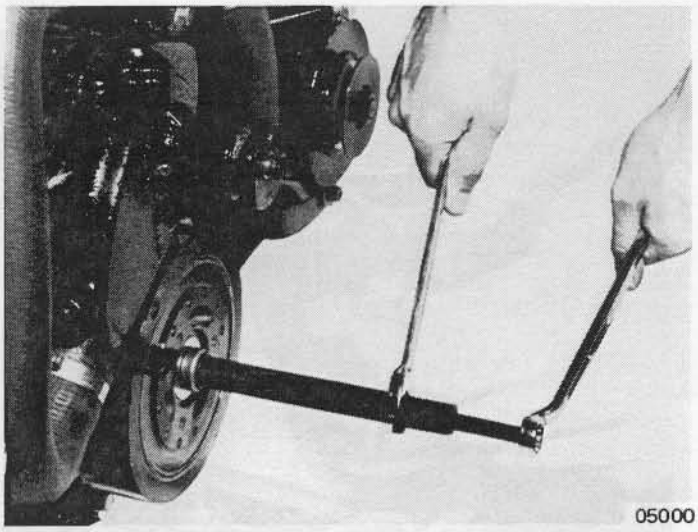
NOTE: Tool J-6978 contains holes forming 2 patterns, a 2-bolt and a 3-bolt pattern. Holes for the 2-bolt pattern must be elongated.

3. Install tool J-6978 on damper and, turning puller screw, remove damper. (Figure 5)

INSTALLATION

CAUTION: Inertia weight section of torsional damper is assembled to hub with rubber-type material. Installation procedures must be followed, or movement of inertia weight section on hub will destroy tuning of torsional damper. DO NOT drive damper on.

1. Coat front cover seal contact area (on damper) with engine oil.
2. Install damper on crankshaft as follows:
   a. Place damper in position over key on crankshaft.
   b. Pull torsional damper onto crankshaft. Use tool J-21058. (Figure 6) If not available, pull damper on with a thick flat washer, a full-threaded ½-20x5" bolt and a ½-20 nut.



CAUTION: Install installing tool bolt in crankshaft with sufficient thread engagement (minimum ½" [12.7mm]).

c. Remove tool from crankshaft, then install damper retaining bolt and torque to specifications.
3. Install drive pulley.
4. Install drive belts.

Figure 6. Installing Torsional Damper

CRANKCASE FRONT COVER

REMOVAL

1. Remove oil pan as outlined.
2. Remove torsional damper as instructed.
3. Remove water pump.
4. Remove crankcase front cover attaching screw. Remove front cover and gasket.

INSTALLATION

1. Make certain that cover and cylinder block mating surface are clean and flat.
2. Coat oil seal with engine oil and, using a new cover gasket coated with Perfect Seal (C-92-34227), install cover and gasket over dowel pins on cylinder block.
3. Install cover screws and torque to specifications.
4. Install water pump.
5. Install torsional damper as described.
6. Install oil pan as outlined.

OIL SEAL

REPLACEMENT (with COVER REMOVED)

1. With cover removed, pry old seal out of cover from the front with a large screwdriver.

CAUTION: Support cover at seal area when installing seal. (Tool J-971 may be used as support.)

2. Install new seal so that open end of seal is toward inside of cover and drive it into position with tool J-22102. (Figure 7)

NOTE: Some left handed engines have helical grooves in seal.

REPLACEMENT (without COVER REMOVED)

1. With torsional damper removed, pry seal out of cover from the front with a large screwdriver, being careful not to damage surface on crankshaft.

Figure 7. Installing Oil Seal (Cover Removed)

2. Install new seal so that open end of seal is toward inside of cover and drive it into position with tool J-22102. (Figure 8)

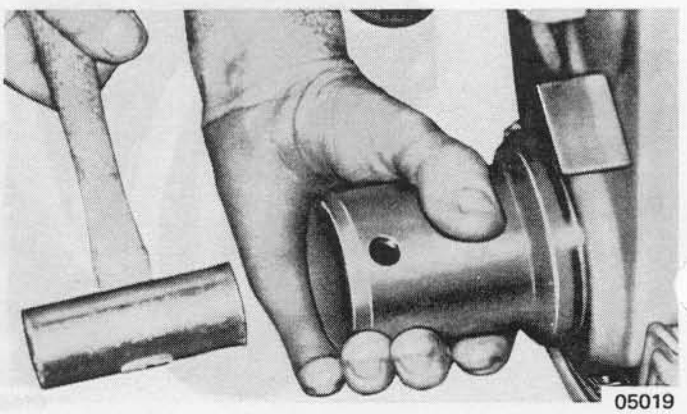


Figure 8. Installing Oil Seal (Cover Installed)

FLYWHEEL

REMOVAL

1. Remove engine from boat.
2. Remove transmission, if so equipped.
3. Remove flywheel housing and drive plate.
4. Remove flywheel.

INSPECTION

1. Inspect drive plate for wear.
2. Check flywheel ring gear for worn or missing teeth.

INSTALLATION

1. Clean mating surfaces of flywheel and crankshaft.
2. Install flywheel on crankshaft and align dowel hole of crankshaft flange and flywheel. (Figure 12)
3. Install coupler or drive plate.
4. Check flywheel runout by mounting dial indicator on machined surface of flywheel.
5. Runout should not exceed .008" (.203mm). If excessive, remove flywheel and check for burrs or replace flywheel.
6. Replace bell housing.
7. Install transmission, if so equipped.
8. Install engine in boat.

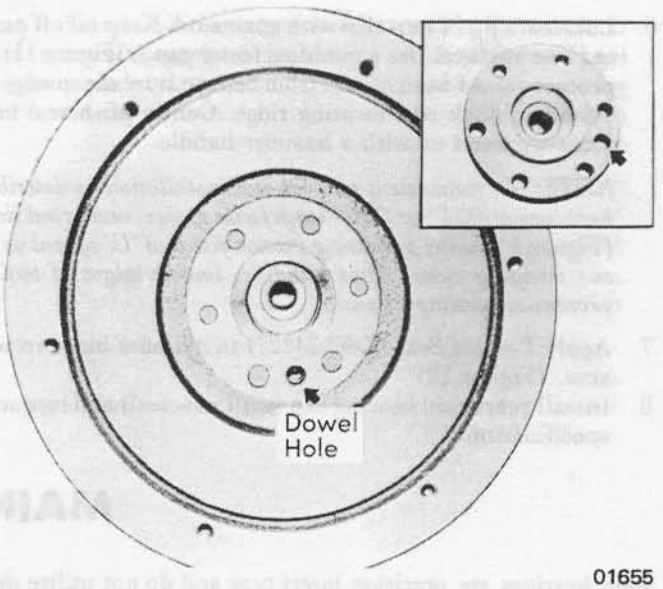


Figure 9. Flywheel Positioned on Crankshaft Flange

OIL SEAL (REAR MAIN)

REPLACEMENT

Rear main bearing oil seal can be replaced (both halves) without removing crankshaft.

NOTE: Always replace upper and lower seal as a unit. Install with lip facing toward front of engine.

1. Remove oil pan and oil pump as outlined.
2. Remove rear main bearing cap.

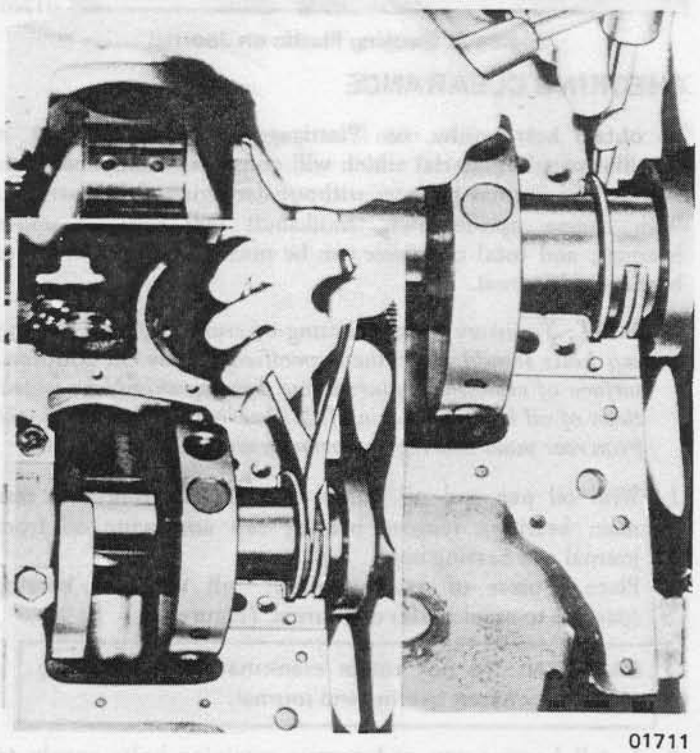


Figure 10. Removing Oil Seal (Upper Half)

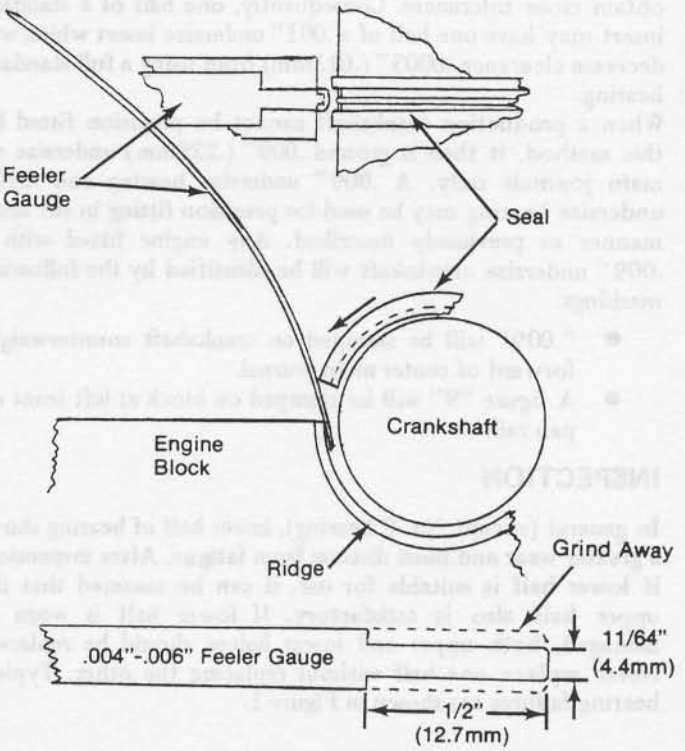


Figure 11. Installing Rear Main Seal-Cylinder Block Inverted

3. Remove oil seal from rear main bearing cap by prying from bottom with a small screwdriver.
4. Lubricate lip of new seal with engine oil. Keep oil off parting line surface, as this is treated with glue. Insert seal into cap carefully, without allowing sharp edge of ridge to cut raised bead in center of seal outer surface.
5. To remove upper half of seal, use a small hammer and tap a brass pin punch on one end of seal until it protrudes far enough to be removed with pliers. (Figure 10)

NOTE: Always wipe crankshaft surface clean before installing a new seal.

6. Lubricate lip of new seal with engine oil. Keep oil off parting line surface. Use a modified feeler gauge (Figure 11) to protect raised bead of seal from being cut by sharp edge of cylinder block seal locating ridge. Gently push seal into place by hand or with a hammer handle.

   NOTE: To fabricate a tool for seal installation as described here, use a .004" or .006" stock feeler gauge, and grind sides (Figure 11) until projecting portion fits into 'U' of seal without scraping sides. After grinding, smooth edges of tool to prevent scratching of seal.

7. Apply Perfect Seal (C-92-34227) to cylinder block in seal area. (Figure 12)
8. Install rear main bearing cap (with new seal) and torque to specifications.

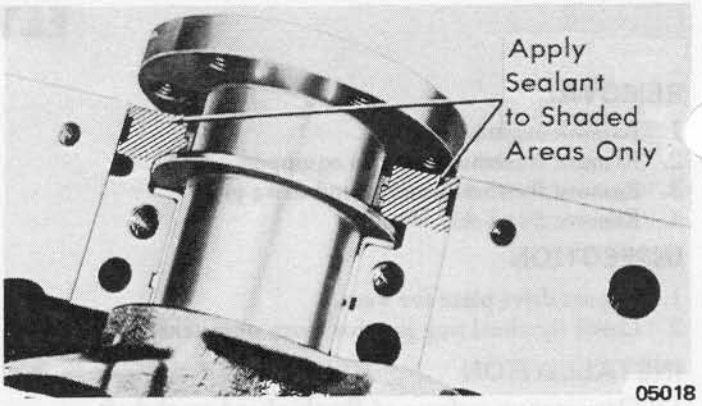


Figure 12. Sealing Bearing Cap and Block

9. Install oil pump and oil pan as outlined.

MAIN BEARINGS

Main bearings are precision insert type and do not utilize shim for adjustment. If clearances are excessive, a new bearing (both upper and lower halves) will be required. Bearings are available in standard size and .001", .002", .010" and .020" (.025mm, .051mm, .254mm and .508mm) undersize. Selective fitting of both rod and main bearing inserts is necessary in production to obtain close tolerances. Consequently, one half of a standard insert may have one half of a .001" undersize insert which will decrease clearance .0005" (.013mm) from using a full standard bearing.

When a production crankshaft cannot be precision fitted by this method, it then is ground .009" (.229mm) undersize on main journals only. A .009" undersize bearing and .010" undersize bearing may be used for precision fitting in the same manner as previously described. Any engine fitted with a .009" undersize crankshaft will be identified by the following markings:

- ".009" will be stamped on crankshaft counterweight forward of center main journal.
- A figure "9" will be stamped on block at left front oil pan rail.

INSPECTION

In general (except No. 2 bearing), lower half of bearing shows a greater wear and most distress from fatigue. After inspection, if lower half is suitable for use, it can be assumed that the upper half also is satisfactory. If lower half is worn or damaged, both upper and lower halves should be replaced. Never replace one half without replacing the other. Typical bearing failures are shown in Figure 1.

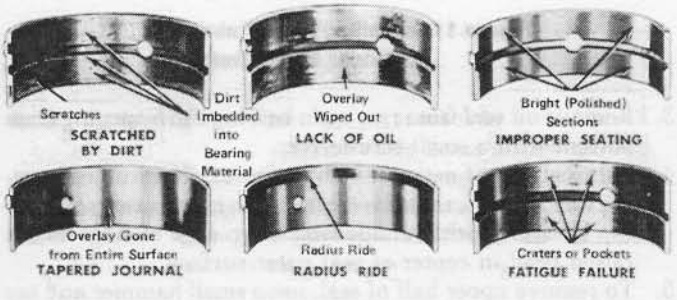


Figure 1. Typical Bearing Failure

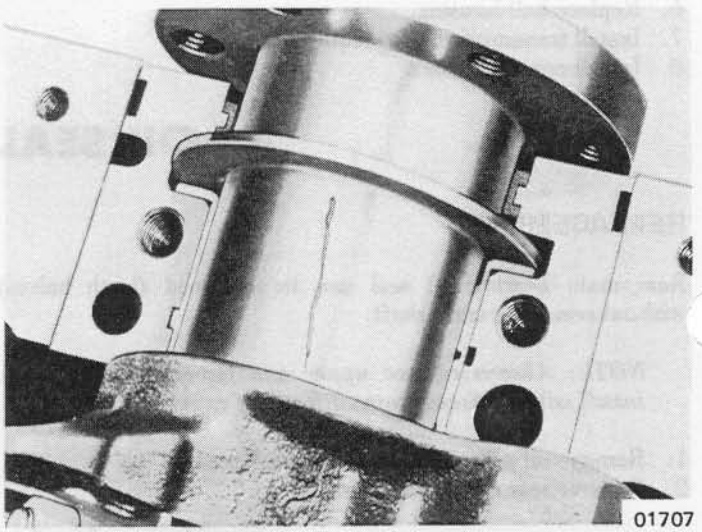


Figure 2. Gauging Plastic on Journal

CHECKING CLEARANCE

To obtain best results, use Plastigage (or its equivalent), a wax-like plastic material which will compress evenly between bearing and journal surfaces without damaging either surface. With engine upside-down, crankshaft will rest on upper bearings, and total clearance can be measured between lower bearing and journal.

NOTE: To assure proper seating of crankshaft, all bearing cap bolts should be at their specified torque. In addition, surface of crankshaft journal and bearing should be wiped clean of oil before checking fit of bearings. Remove oil seal from rear main bearing cap prior to checking clearance.

1. With oil pan and oil pump removed (starting with rear main bearing), remove bearing cap and wipe oil from journal and bearing cap.
2. Place a piece of gauging plastic full width of bearing (parallel to crankshaft) on journal. (Figure 2)

CAUTION: Do not rotate crankshaft while gauging plastic is between bearing and journal.

3. Install bearing cap and torque retaining bolts evenly to specifications.

4. Remove bearing cap. Flattened gauging plastic will be found adhering to either bearing shell or journal.
5. Use graduated scale (correlated in thousandths of an inch) on edge of gauging plastic envelope. Without removing gauging plastic, measure its compressed width (at widest point) with graduations on gauging plastic envelope. (Figure 3)

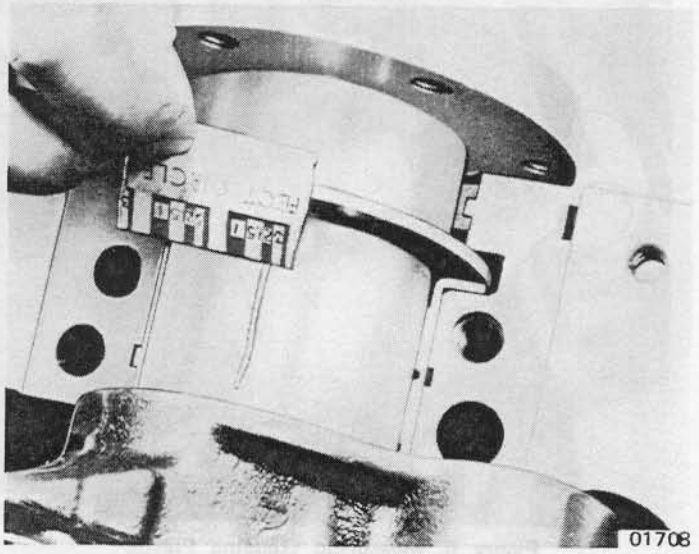


Figure 3. Measuring Gauging Plastic

NOTE: Main bearing journals usually wear evenly and are not out-of-round. However, if a bearing is being fitted to an out-of-round journal (.001" [.025mm] maximum), be sure to fit to maximum diameter of journal. If bearing is fitted to minimum diameter, and journal is out-of-round .001", interference between bearing and journal will result in rapid bearing failure. If flattened gauging plastic tapers toward middle or ends, there is a difference in clearance indicating taper, low spot or other irregularity of bearing or journal. Be sure to measure journal with a micrometer if flattened gauging plastic indicates more than .001" difference.

6. If bearing clearance is within specifications, bearing insert is satisfactory. If clearance is not within specifications, replace the insert. Always replace both upper and lower insert as a unit.

NOTE: If a new bearing cap is being installed and clearance is less than .001", inspect for burrs or nicks.

7. A standard .001" or .002" (.025mm or .051mm) undersize bearing may produce proper clearance. If not, regrind crankshaft journal for use with next undersize bearing.
8. Proceed to next bearing. After all bearings have been checked, rotate crankshaft to see that excessive drag does not exist.
9. Measure crankshaft end play (see specifications) by forcing crankshaft to extreme front position. Measure at front end of rear main bearing with a feeler gauge. (Figure 4)
10. Install a new rear main bearing oil seal in cylinder block and main bearing cap.

REPLACEMENT

NOTE: Main bearings may be replaced with or without removing crankshaft.

WITH CRANKSHAFT REMOVED

1. Remove and inspect crankshaft.
2. Remove main bearings from cylinder block and main bearing caps.
3. Coat bearing surfaces of new, correct size, main bearings with oil and install in cylinder block and main bearing caps.
4. Install crankshaft.

WITHOUT CRANKSHAFT REMOVED

1. With oil pan, oil pump and spark plugs removed, remove cap on main bearing requiring replacement and remove bearing from cap.
2. Replace main bearing upper half as follows:
   a. Install main bearing removing and installing tool in crankshaft journal oil hole.

   NOTE: If tool is not available, bend a cotter pin.

   b. Rotate crankshaft clockwise (as viewed from front of engine). This will roll upper bearing out of block.
   c. Oil new selected size upper bearing and insert plain (unnotched) end between crankshaft and notched side of block. Rotate bearing into place and remove tool from oil hole in crankshaft journal.
3. Oil new lower bearing and install in bearing cap.
4. Install main bearing cap with arrows pointing toward front of engine.
5. Torque main bearing cap bolts to specifications.

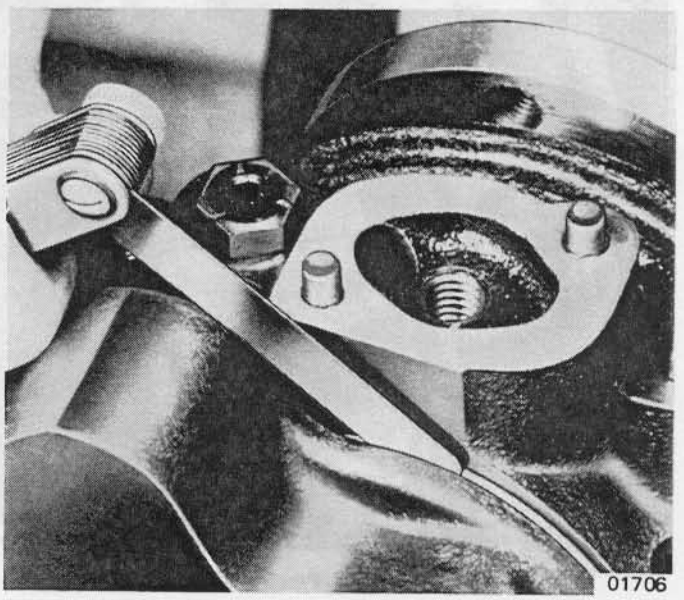


Figure 4. Measuring Crankshaft End Play

CONNECTING ROD BEARINGS

Connecting rod bearings are precision insert type and do not utilize shims for adjustment. DO NOT FILE RODS OR ROD CAPS. If clearances are found to be excessive, a new bearing will be required. Bearings are available in standard size and .001" and .002" undersize for new and used standard size crankshafts and in .010" and .020" - undersize for reconditioned crankshafts. (.001"=.025mm)

INSPECTION and REPLACEMENT

1. With oil pan and oil pump removed, remove connecting rod cap and bearing.
2. Inspect bearing for wear or damage and replace unsatisfactory bearings. Typical bearing failures are shown in Figure 1.
3. Wipe bearings and crankpin clean of oil.
4. Measure crankpin for out-of-round or taper with a micrometer. If not within specifications, replace or recondition crankshaft. If within specifications, and a new bearing is to be installed, measure maximum diameter of crankpin to determine new bearing size required.
5. Measure new or used bearing clearances with Plastigage or its equivalent.

   NOTE: If a bearing is being fitted to an out-of-round crankpin, be sure to fit to maximum diameter of crankpin. If bearing is fitted to minimum diameter, and crankpin is out-of-round .001" (.025mm) or more, interference between bearing and crankpin will result in rapid bearing failure.

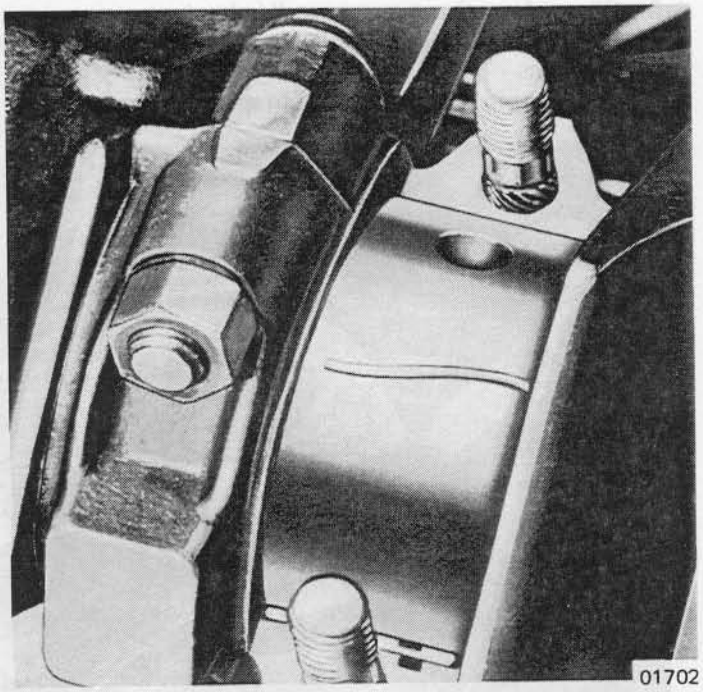


Figure 5. Gauging Plastic on Crankpin

   a. Install bearing in connecting rod and cap.
   b. Place a piece of gauging plastic the full width of crankpin (parallel to crankshaft). (Figure 5)
   c. Install bearing cap and torque nuts evenly to specifications.

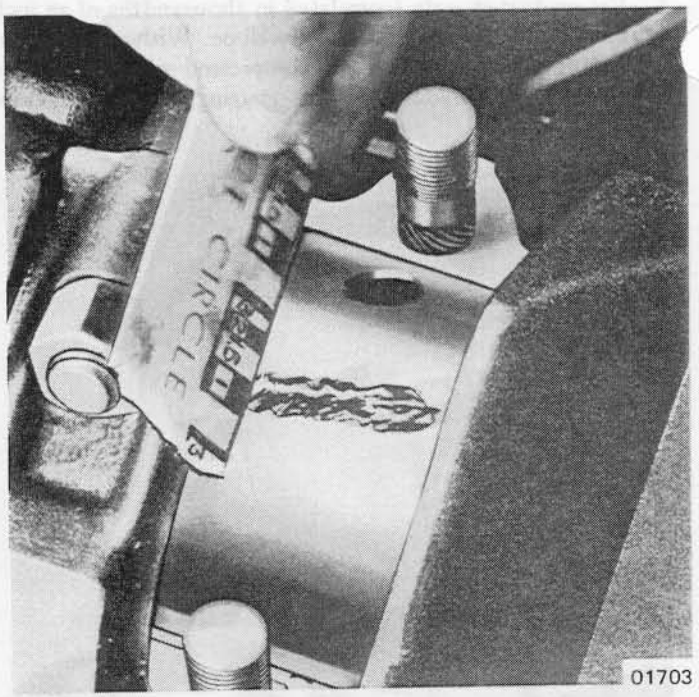


Figure 6. Measuring Gauging Plastic

CAUTION: Do not turn crankshaft with gauging plastic installed.

   d. Remove bearing cap and, using scale on gauging plastic envelope, measure gauging plastic width at the widest point. (Figure 6)

6. If clearance exceeds specifications, select a new, correct size bearing and recheck clearance.
7. Coat bearing surface with oil, install rod cap and torque nuts to specifications.
8. When all connecting rod bearings have been installed, tap each rod lightly (parallel to crankpin) to make sure they have clearance.
9. Measure all connecting rod side clearances (see specifications) between connecting rod caps. (Figure 7)

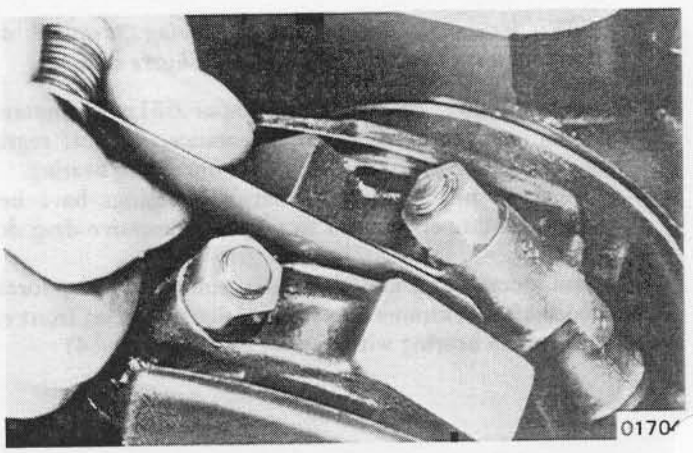


Figure 7. Measuring Connecting Rod Side Clearance

CONNECTING ROD and PISTON ASSEMBLY

REMOVAL

1. With oil pan, oil pump and cylinder head removed, use a ridge reamer to remove any ridge and/or deposits from upper end of cylinder bore.

   NOTE: Before ridge and/or deposits are removed, turn crankshaft until piston is at bottom of stroke and place a cloth on top of piston to collect cuttings. After ridge and/or deposits are removed, turn crankshaft until piston is at top of stroke, then remove cloth and cuttings.

2. Mark connecting rod and bearing caps left bank 1, 3, 5 and 7; right bank 2, 4, 6 and 8 from front to rear on same side as piston thrust.
3. Remove connecting rod cap and install tool J-5239 (3/8") or J-6305 (11/32") on studs. (Figure 8) Push connecting rod and piston assembly out of top of cylinder block.

   NOTE: It will be necessary to turn crankshaft slightly to disconnect and remove some connecting rod and piston assemblies.

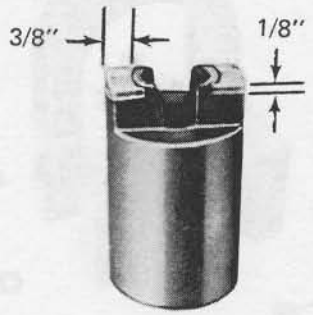
DISASSEMBLY

Method 1

PISTON SUPPORT TOOL

If bosses on pistons do not allow piston support tool J-9510-1 to seat squarely on piston for press operations, tool modifications are necessary. To allow adequate clearance for these bosses, turn or grind upper portion of tool to dimensions shown in Figure 9. Tool modification, as described, does not affect tool application on other pistons.

Figure 8. Removing Piston Assemblies



3/8" = 9.5mm 1/8" = 3.2mm

Figure 9. Piston Support Tool Modification

1. Remove connecting rod bearings from connecting rods and caps.

   NOTE: If connecting rod bearings are being reused, place them in a rack to aid in reinstalling in their original rod and cap.

2. Remove piston rings with ring expander.
3. Place connecting rod and piston assembly in arbor press with piston on support. Press piston pin out of connecting rod and piston with piston pin tool J-6994. (Figure 10)
4. Remove assembly from arbor press and remove tools, piston pin, connecting rod and piston.

Method 2

1. Use Tool Kit (J-24086-100), shown in Figure 11.

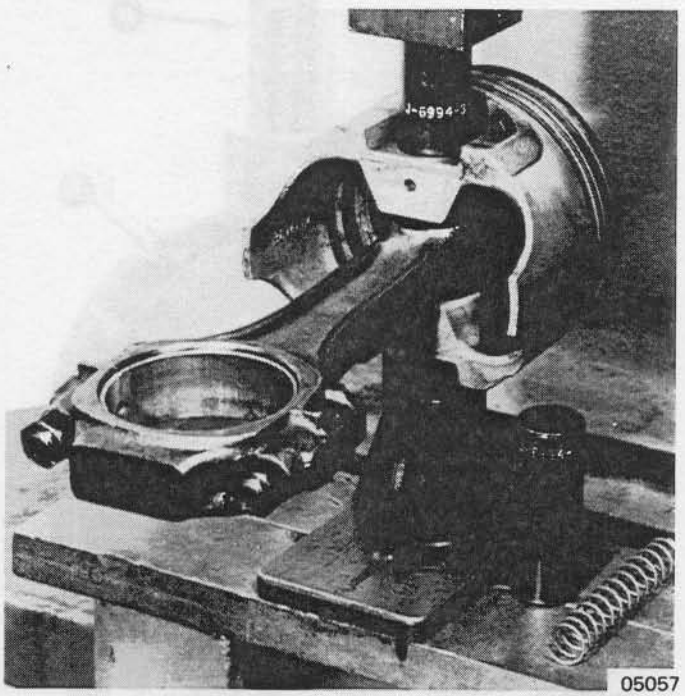
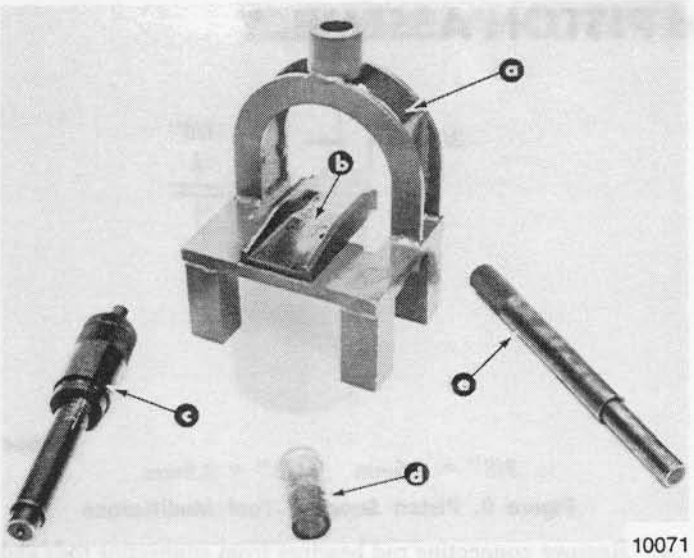


Figure 10. Removing Piston

2. Position connecting rod onto tool rod support with rod support inserted between connecting rod end and piston. Align piston pin with hole located in top of arched base. (Figure 12)
3. Insert pin remover thru hole (located in top of arched base) and into piston pin hole. Press on pin remover to remove piston pin. (Figure 12)



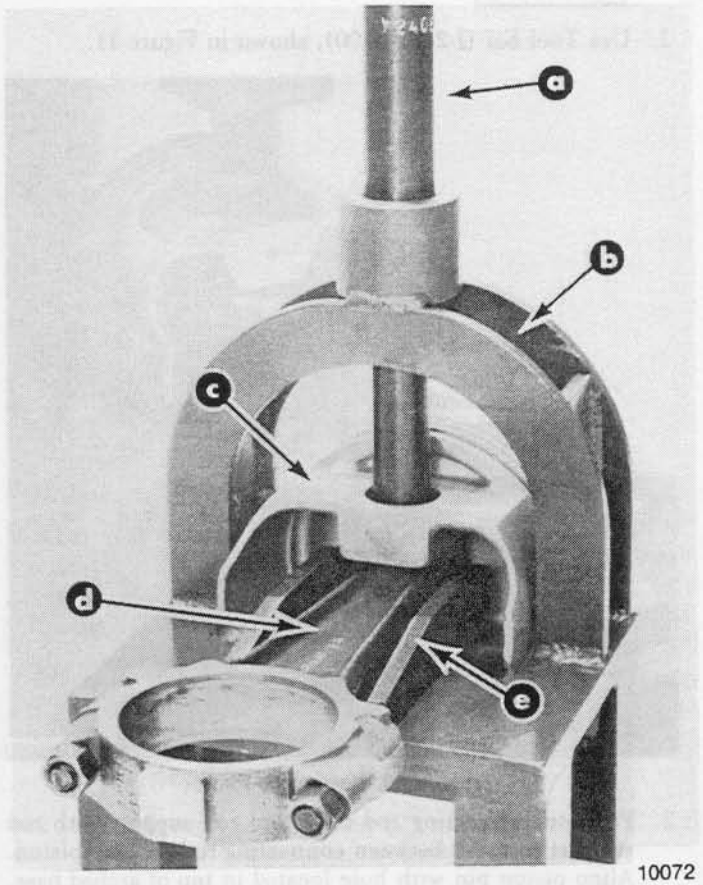
a - Arched Base
b - Rod Support
c - Adjustable Installer
d - Piston Pin Guide
e - Piston Pin Remover

Figure 11. Tool (J-24086-100) Parts Identification

CLEANING and INSPECTION

CONNECTING RODS

1. Wash connecting rods in cleaning solvent and dry with compressed air.
2. Check for twisted or bent rods and inspect for nicks or cracks. Replace damaged connecting rods.



a - Piston Pin Remover
b - Arched Base
c - Piston
d - Connecting Rod
e - Rod Support

Figure 12. Removing Piston Pin

PISTONS

1. Clean varnish from piston skirts and pins with a cleaning solvent. DO NOT WIRE BRUSH ANY PART OF PISTON. Clean ring grooves with a groove cleaner and make sure oil ring holes and slots are clean.
2. Inspect piston for cracked ring lands, skirts or pin bosses, wavy worn ring lands, scuffed or damaged skirts or eroded areas at top of piston. Replace pistons which are damaged or show signs of excessive wear.
3. Inspect grooves for nicks or burrs that might cause rings to hang up.
4. Measure piston skirt (across centerline of piston pin) and check clearance as outlined under "Piston Selection". (Use "Index".)

PISTON PINS

1. Piston pin clearance is designed to maintain adequate clearance under all engine operating conditions. Because of this, piston and piston pin are a matched set and not serviced separately.
2. Inspect piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when measured. Measure piston pin with a micrometer and piston pin bore with a dial bore gauge or inside micrometer. If clearance is in excess of the .001" (.025mm) wear limit, replace piston and piston pin assembly.

PISTON RINGS

All compression rings are marked on upper side of ring. When installing compression rings, make sure that marked side is toward top of piston.

Oil control rings are a 3-piece type, consisting of 2 segments (rails) and a spacer.

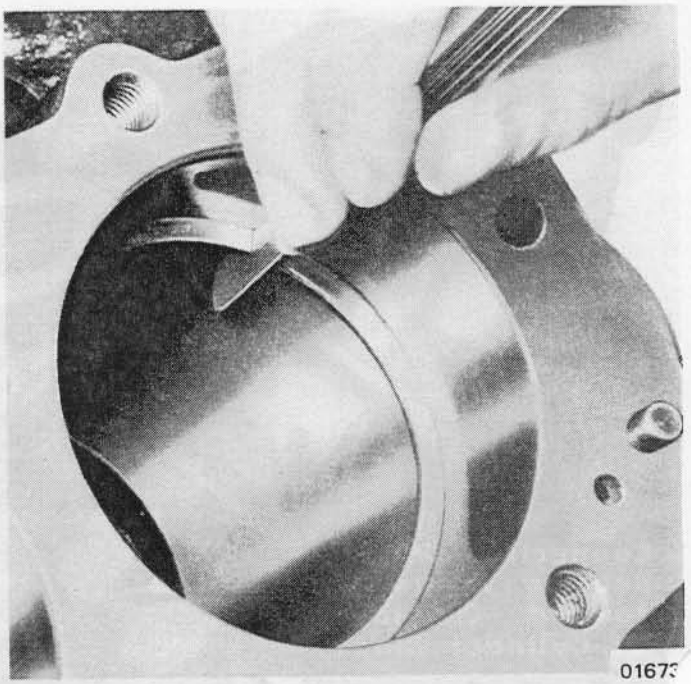


Figure 13. Checking Ring Gap

1. Select rings comparable in size to piston being used.
2. Slip compression ring in cylinder bore, then press ring down into cylinder bore about ¼" (6.35mm) (above ring travel). Be sure that ring is square with cylinder wall.

3. Measure space or gap between ends of ring with a feeler gauge. (Figure 13)
4. If gap between ends of ring is below specifications, remove ring and try another for fit.
5. Fit each compression ring to cylinder in which it is going to be used.
6. Clean and inspect pistons, if not previously done.
7. Slip outer surface of top and second compression ring into respective piston ring groove and roll ring entirely around the groove (Figure 14) to make sure that ring is free. If binding occurs at any point, determine cause. If caused by ring groove, remove by dressing with a fine cut file. If binding is caused by a distorted ring, check a new ring.

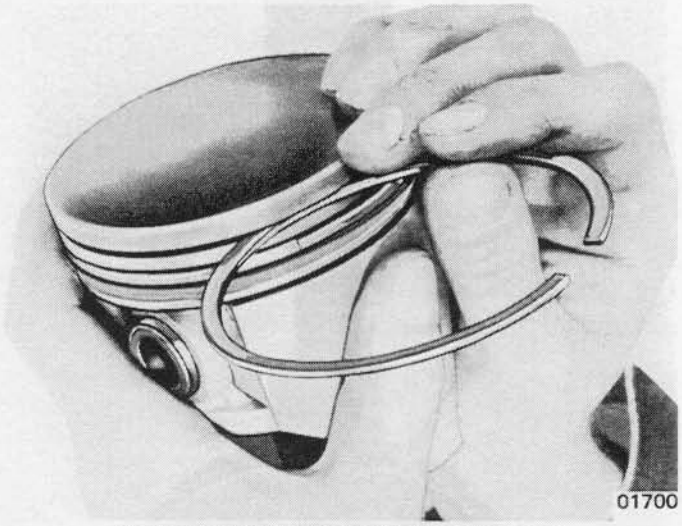


Figure 14. Rolling Ring in Ring Groove

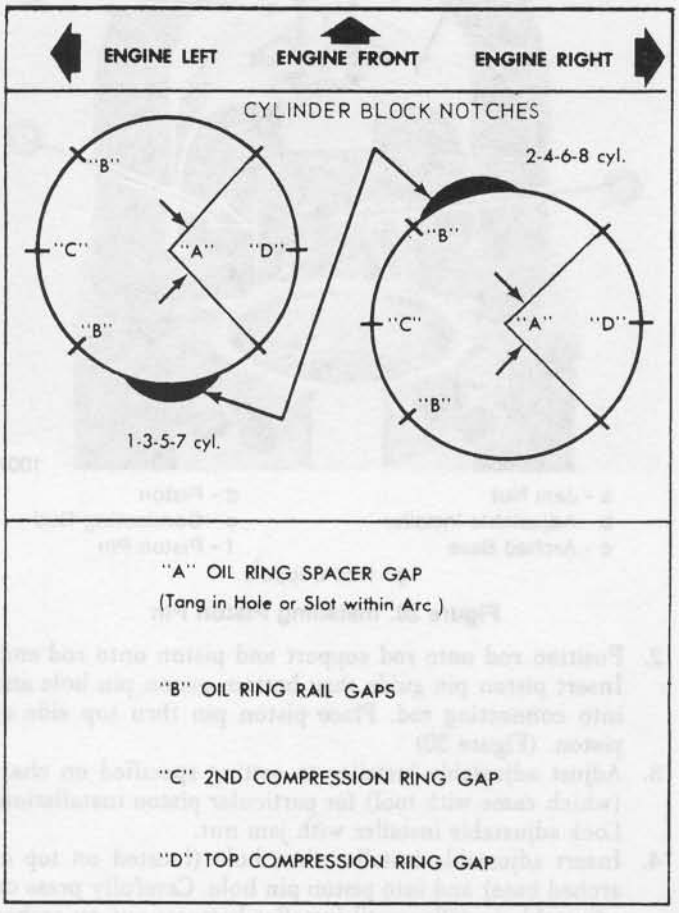


Figure 15. Ring Gap Location

8. Install piston ring as shown in Figure 15. Use (J-22250) piston ring expanders for compression ring installation.
   a. Install oil ring spacer in groove and insert anti-rotation tang in oil hole.
   b. Hold spacer ends butted and install lower steel oil ring rail with gap properly located.
   c. Install upper steel oil ring rail with gap properly located.
   d. Flex the oil ring assembly to make sure ring is free. If binding occurs at any point, the cause should be determined and, if caused by ring groove, remove by dressing groove with a fine cut file. If binding is caused by a distorted ring, check a new ring.
   e. Install lower compression ring, using ring expander, and check location of gap.
   f. Install top compression ring with gap properly located.
9. Proper clearance of piston ring in its piston ring groove is very important to provide proper ring action and reduce wear. Therefore, when fitting new rings, clearances between ring and groove surfaces should be measured. (Figure 16) See "Specifications" Section 8.

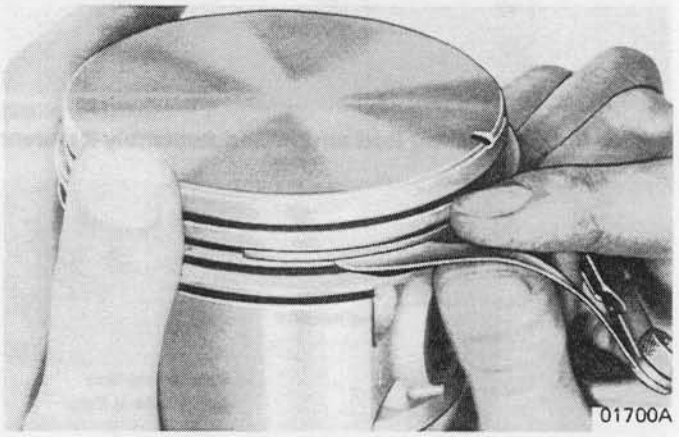


Figure 16. Checking Groove Clearance

REASSEMBLY

Method 1

CAUTION: DO NOT oil piston pin or connecting rod before rod end is to be heated for installation.

1. Heat piston pin end of connecting rod.

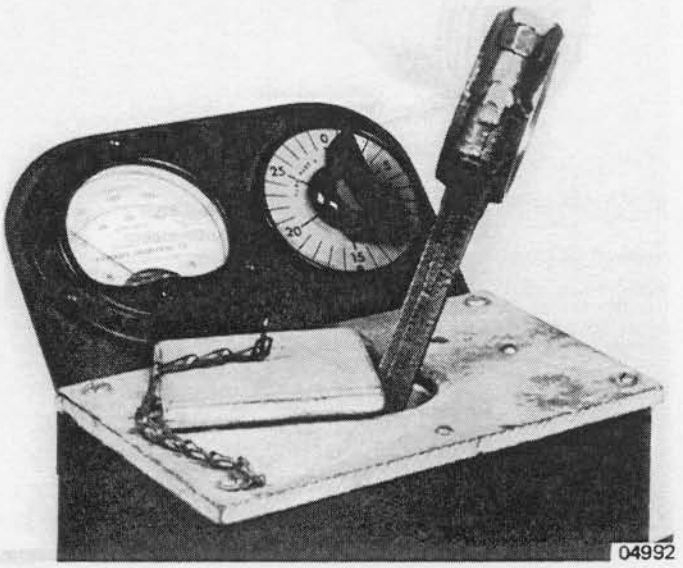


Figure 17. Connecting Rod and Oven

NOTE: An oven is recommended to heat piston pin end of connecting rod prior to piston installation. (Figure 17)

2. Place support tool J-6994 with spring and pilot in place on arbor press.
3. Position piston on connecting rod with notched side of piston (Figure 18) and connecting rod tangs aligned.

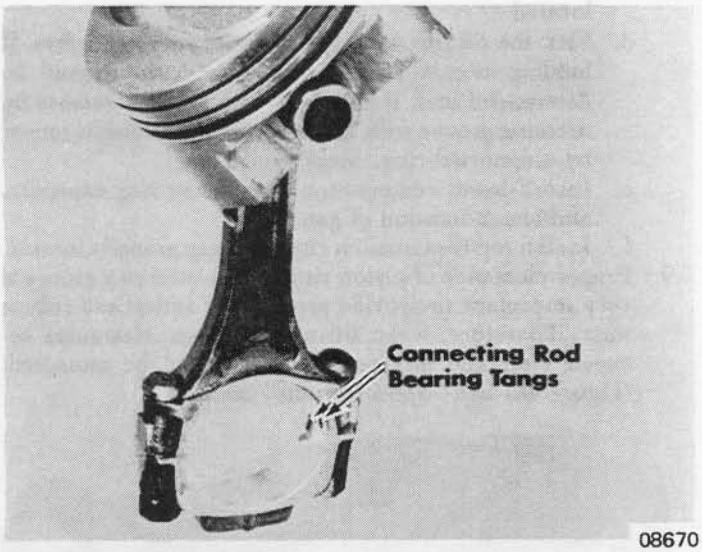


Figure 18. Connecting Rod and Piston Assembly Reference

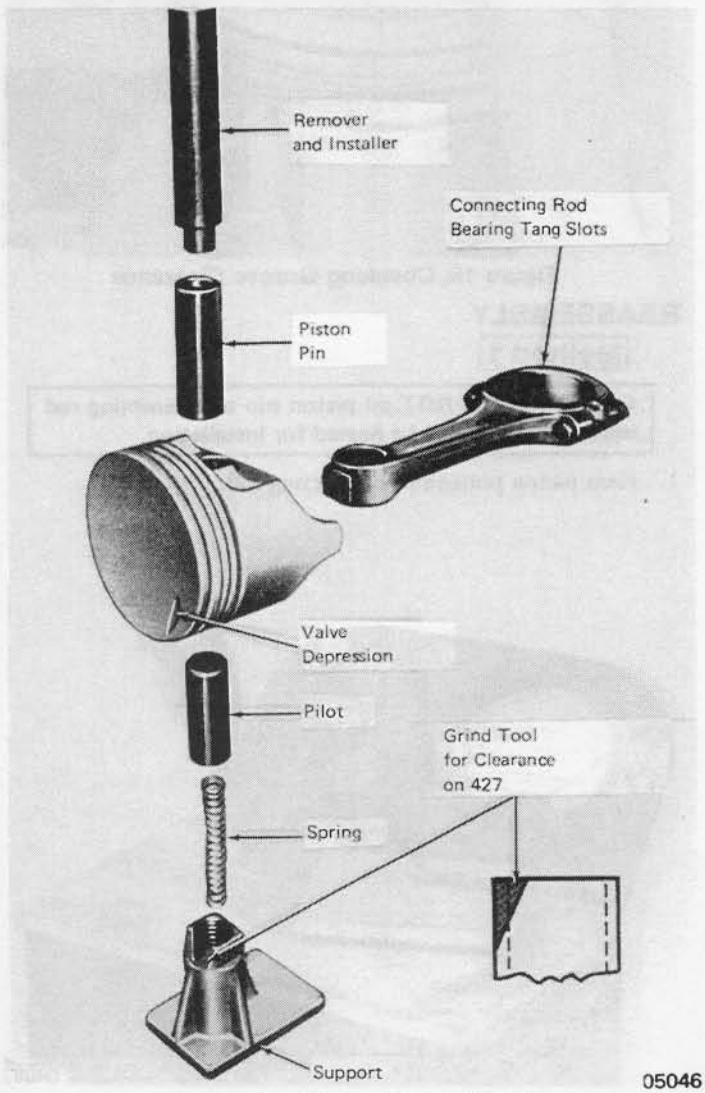
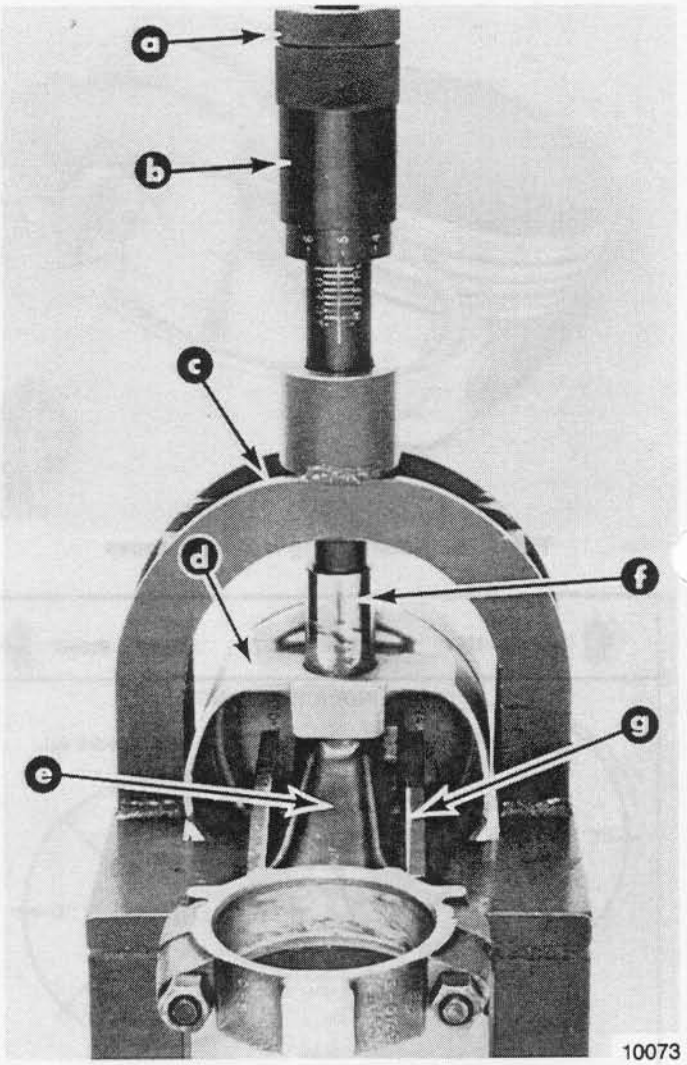


Figure 19. Piston Pin and Tool

4. Place piston on support, indexing pilot through piston and rod.
5. Place installer (Figure 19) on piston pin, start piston pin and press on installer until pilot bottoms in support.
6. Remove installer from connecting rod and piston assembly and check piston for freedom of movement on piston pin.
7. Allow connecting rod and piston assembly to cool, then oil piston pin.

Method 2

1. Lubricate piston pin, piston pin hole in piston and hole in rod end with a light coat of engine oil.



a - Jam Nut
b - Adjustable Installer
c - Arched Base
d - Piston
e - Connecting Rod
f - Piston Pin
g - Rod Support

Figure 20. Installing Piston Pin

2. Position rod onto rod support and piston onto rod end. Insert piston pin guide thru bottom piston pin hole and into connecting rod. Place piston pin thru top side of piston. (Figure 20)
3. Adjust adjustable installer to setting specified on chart (which came with tool) for particular piston installation. Lock adjustable installer with jam nut.
4. Insert adjustable installer thru hole (located on top of arched base) and into piston pin hole. Carefully press on adjustable installer until installer bottoms-out on arched base to install piston pin.

INSTALLATION

NOTE: Cylinder bores must be clean before piston installation. Clean with a light honing, as necessary. Then clean with hot water and detergent wash. After cleaning, swab bores several times with light engine oil and a clean cloth, then wipe with a clean dry cloth.

1. Lubricate connecting rod bearings and install in rods and rod caps.
2. Lightly coat pistons, rings and cylinder walls with light engine oil.
3. With bearing caps removed, install tool J-6305 (11/32") on connecting rod bolts.

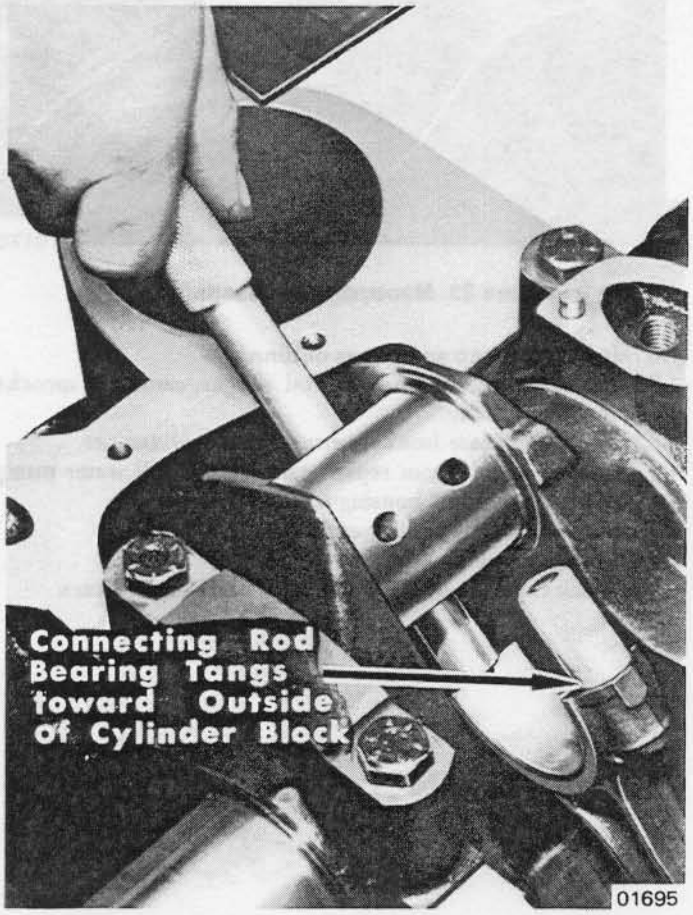


Figure 21. Connecting Rods-Installed Position - V-8

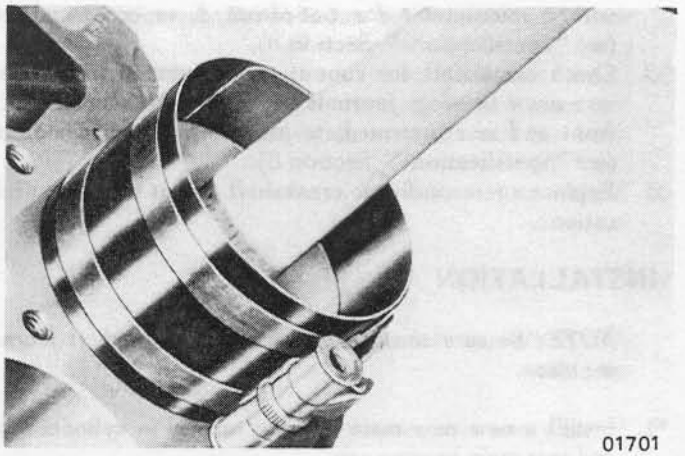


Figure 22. Installing Connecting Rod and Piston Assemblies

CAUTION: Be sure ring gaps are properly positioned as previously outlined.

4. Install each connecting rod and piston assembly in its respective bore. Install with connecting rod bearing tangs toward outside of cylinder block. (Figure 21) Use tool J-8307 to compress rings. (Figure 22) Guide connecting rod into place on crankshaft journal with tool J-6305 (11/32"). Use a hammer handle with light blows to install piston into bore. Hold ring compressor firmly against cylinder block until all piston rings have entered cylinder bore. (Figure 22)

   NOTE: Be sure to install new pistons in same cylinders for which they were fitted, and used pistons in same cylinder from which they were removed. Each connecting rod and bearing cap should be marked, beginning at front of engine (1, 3, 5 and 7 in left bank and 2, 4, 6 and 8 in right bank). Numbers on connecting rod and bearing cap must be on same side when installed in cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, new bearings should be fitted and connecting rod should be numbered to correspond with new cylinder number.

5. Remove tool J-6305.
6. Install bearing caps and torque nuts to specification.

   NOTE: If bearing replacement is required, refer to "Connecting Rod Bearings".

CRANKSHAFT

REMOVAL

1. Remove engine from boat.
2. Drain block and crankcase oil. Disconnect all hoses.
3. Remove starter motor, flywheel housing and flywheel. Place engine in repair stand.
4. Remove belts, crankshaft pulley and water pump.
5. Remove torsional damper and crankcase front end cover.
6. Remove spark plugs.
7. Remove camshaft sprocket and timing chain. Remove crankshaft oil slinger.
8. Remove crankshaft sprocket.
9. Remove oil pan and oil pump.
10. Make sure all bearing caps (main and connecting rods) are marked so they can be installed in their original locations. Remove connecting rod bearing caps, then push piston and rod assemblies toward heads.
11. Remove main bearing caps and carefully lift crankshaft out of cylinder block. Remove rear main bearing oil seal from cylinder block and rear main bearing cap.
12. If new main and/or connecting rod bearings are to be installed, remove main bearing inserts from cylinder block and bearing caps, and/or connecting rod bearing inserts from connecting rod and caps. Install new bearings following procedures outlined in this section. (See "Index".)

CLEANING and INSPECTION

1. Wash crankshaft in solvent and dry with compressed air.
2. Measure main bearing journals and crankpin dimensions

with a micrometer for out-of-round, taper or undersize (see "Specifications" Section 8).
3. Check crankshaft for runout (by supporting at front and rear main bearings journals in "V" blocks) and check at front and rear intermediate journals with a dial indicator (see "Specifications" Section 8).
4. Replace or recondition crankshaft if not meeting specifications.

INSTALLATION

NOTE: Be sure that all bearings and crankshaft journals are clean.

1. Install a new rear main bearing oil seal in cylinder block and rear main bearing cap.
2. Carefully lower crankshaft into place. BE CAREFUL not to damage bearing surface.
3. Check clearance of each main bearing,following procedure outlined under "Main Bearing Clearance" in this section; see "Index". If bearing clearances are satisfactory, apply a light coat of engine oil to journals and bearings.
4. Install all bearing caps and bolts. Torque all main bearing cap bolts to specifications. When tightening rear main bearing cap, torque bolts 10 to 12 ft. lbs. (1.4 to 1.7mkg) first, then tap end of crankshaft to the rear with lead hammer (this will locate bearing cap and bearing). Then tap crankshaft forward (this will line up both upper and lower crankshaft bearing thrust surfaces).
5. Check crankshaft end play by forcing crankshaft to its extreme front position. Check at front end of rear main bearing with feeler gauge. (Figure 23) Clearance should be from .001" to .006" (.025mm to .152mm) with new bearing. If greater than maximum .009" (.229mm) clearance, rear main bearing must be replaced.

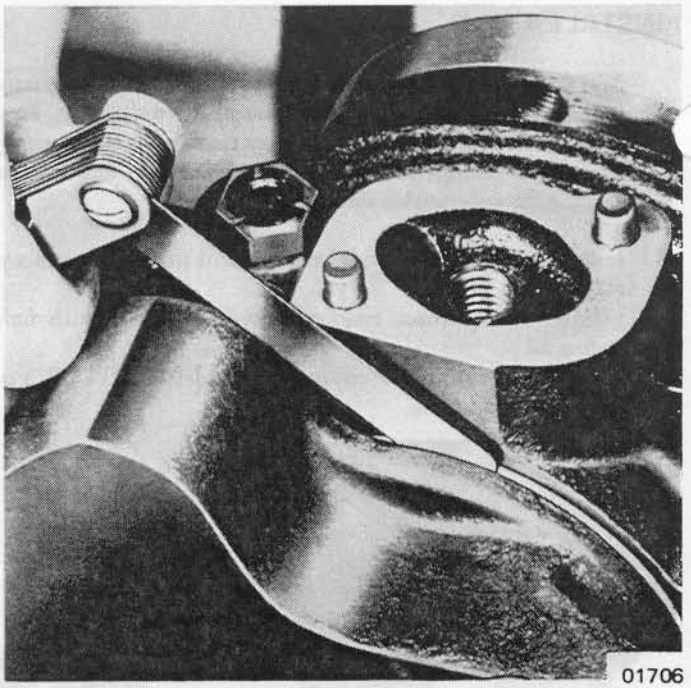


Figure 23. Measuring Crankshaft End Play

6. Install oil pump and pan as outlined.
7. Install crankshaft sprocket, oil slinger, camshaft sprocket and timing chain.
8. Install crankcase front cover and torsional damper.
9. Remove engine from repair stand and install water pump, flywheel, flywheel housing and starter motor.
10. Install crankshaft pulley and belts.
11. Install spark plugs.
12. Install engine in boat, fill crankcase and install hoses.

TIMING CHAIN and/or SPROCKETS

REMOVAL

1. Remove torsional damper and crankcase front cover as outlined.
2. Crank engine until marks on camshaft and crankshaft sprockets are in alignment. (Figure 1)
3. Remove camshaft sprocket to camshaft bolts.
4. Remove camshaft sprocket and timing chain together. Sprocket is a light press fit on camshaft. If sprocket does not come off easily, a light blow on lower edge of sprocket (with a plastic mallet) should dislodge the sprocket.

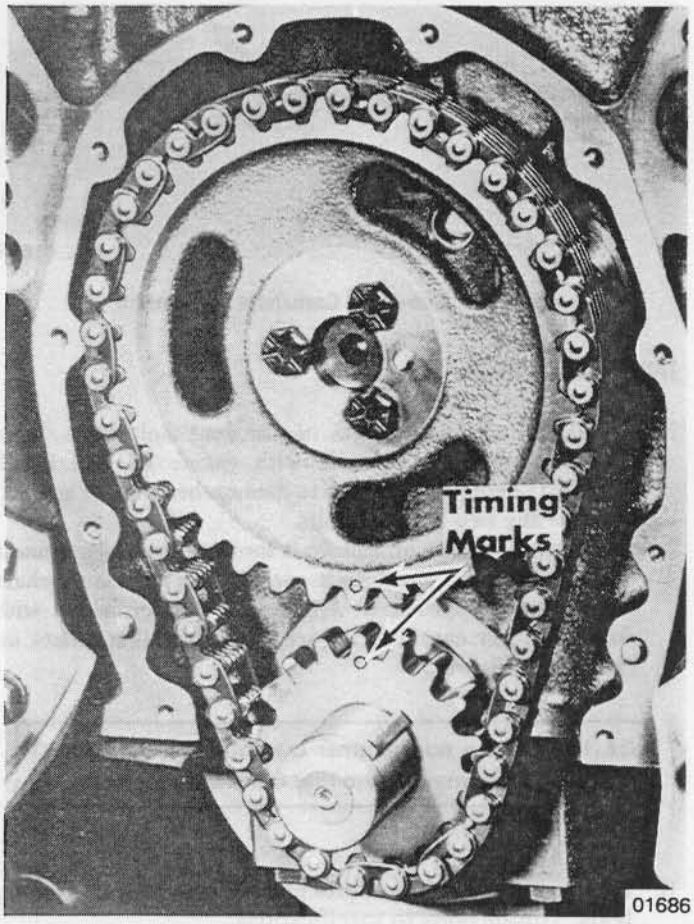


Figure 1. Timing Sprocket Marks

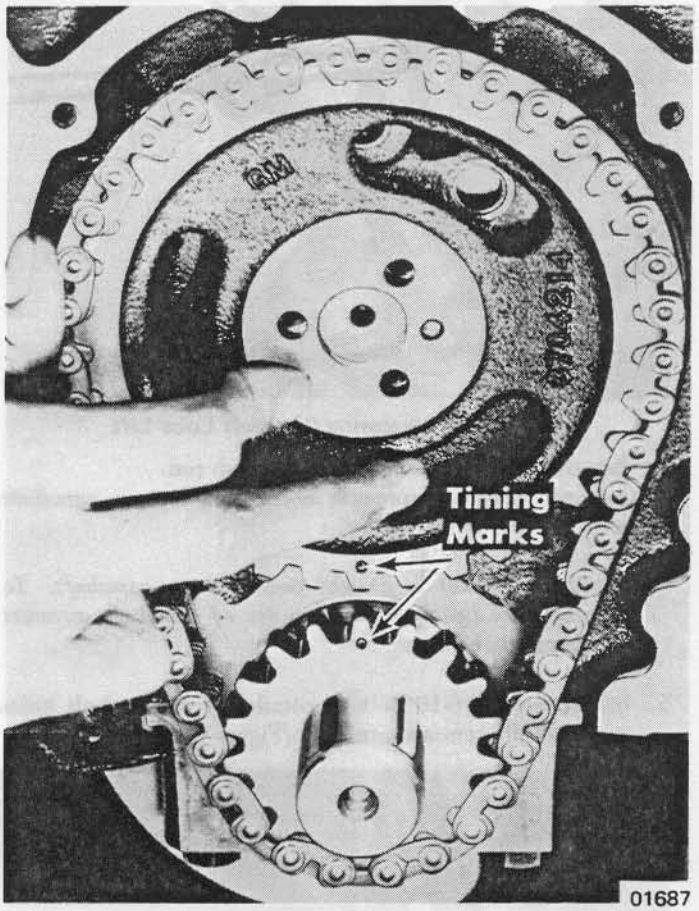


Figure 2. Installing Timing Chain

INSTALLATION

1. Install timing chain on camshaft sprocket. Hold sprocket vertical with chain hanging down and orient to align marks on camshaft and crankshaft sprockets. (Figure 2)

   NOTE: Do not attempt to drive sprocket on camshaft, as welsh plug at rear of engine can be dislodged.

2. Draw camshaft sprocket onto camshaft, using the 3 mounting bolts. Torque to specifications.
3. Lubricate timing chain with engine oil. Install crankcase front cover and torsional damper as outlined.

CAMSHAFT

MEASURING LOBE LIFT

NOTE: Procedure is similar to checking valve timing. If improper valve operation is indicated, measure lift of each push rod in consecutive order and record readings.

1. Remove valve mechanism as outlined (see "Index").
2. Position indicator with ball socket adapter (tool J-8520) on push rod. (Figure 3) Be sure that push rod is in lifter socket.
3. Rotate crankshaft damper slowly in direction of rotation until lifter is on heel of cam lobe. At this point, push rod will be in its lowest position.
4. Set dial indicator on zero, then rotate balancer slowly (or attach an auxiliary starter switch and "bump" engine over) until push rod is in fully raised position.
5. Compare total lift, recorded from dial indicator, with "Specifications" Section 8.
6. Continue to rotate engine until indicator reads zero. This will be a check on accuracy of original indicator reading.
7. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
8. Install and adjust valve mechanism as outlined.

REMOVAL

1. Remove valve lifters as outlined.
2. Remove crankcase front cover as outlined.

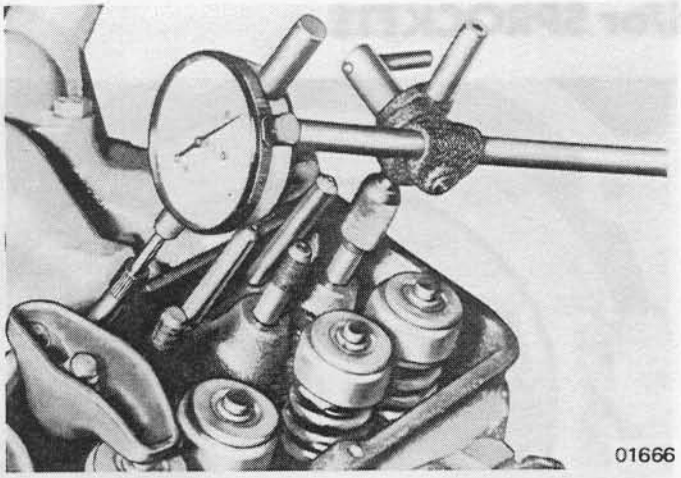


Figure 3. Measuring Camshaft Lobe Lift

3. Remove fuel pump and fuel pump push rod.
4. Remove camshaft sprocket bolts, then remove camshaft sprocket and timing chain.

NOTE: Sprocket is a light press fit on camshaft. To dislodge, tap lightly on lower edge of camshaft sprocket with a plastic hammer.

5. Install two 5/16-18 bolts in camshaft sprocket bolt holes and carefully remove camshaft. (Figure 4)

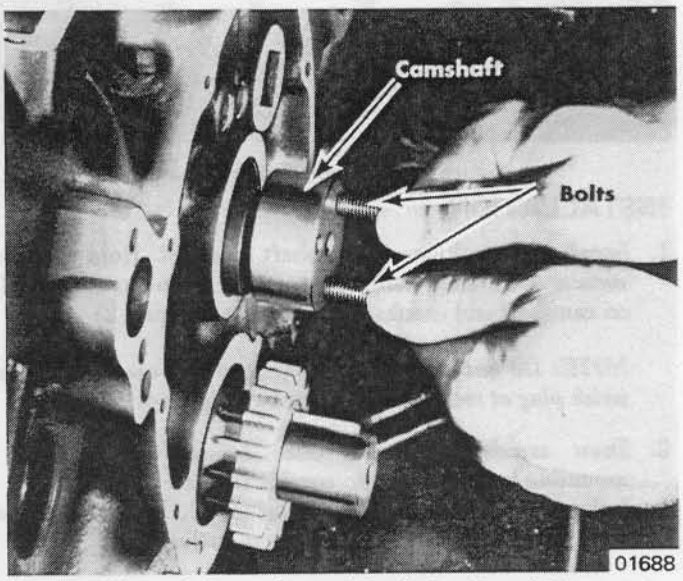


Figure 4. Removing and Replacing Camshaft

INSPECTION

Measure camshaft bearing journals with a micrometer for out-of-round condition. If journals exceed .001" (.025mm) out-of-round, camshaft should be replaced.

Also check camshaft for alignment with "V" blocks and dial indicator (Figure 5) which indicates exact amount camshaft is out-of-true. If out more than .002" (.051mm) (dial indicator reading) camshaft should be replaced.

On engines with timing gears, inspect camshaft gear and thrust plate for wear or damage. Measure camshaft end play which should be .001" to .005" (.025mm to .127mm). (Figure 5)

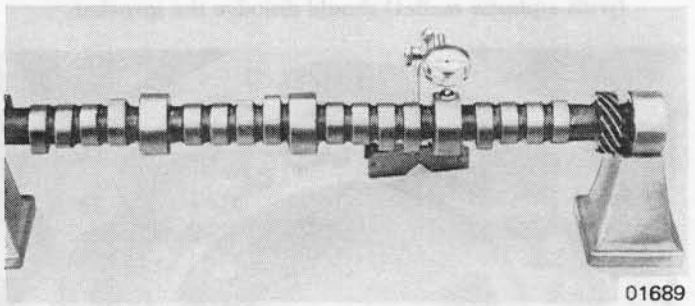


Figure 5. Checking Camshaft Alignment

INSTALLATION

1. Install two 5/16-18 bolts in camshaft bolt holes, then lubricate camshaft journals with engine oil and install camshaft, being careful not to damage bearings. (Figure 4) Remove the two 5/16-18 bolts.
2. Install timing chain on camshaft sprocket, then align marks on camshaft and crankshaft sprockets and connect chain to crankshaft sprocket. Align dowel on camshaft with dowel hole in camshaft sprocket and install sprocket on camshaft. (Figure 2)

CAUTION: Do not hammer crankshaft sprocket onto camshaft. This may loosen rear camshaft welsh plug.

3. Draw camshaft sprocket into camshaft, using the mounting bolts. Torque bolts to specifications.
4. Lubricate timing chain with engine oil.
5. Install fuel pump push rod and fuel pump.
6. Install crankcase front cover and valve lifters as outlined.

CRANKSHAFT SPROCKETS

REMOVAL

1. Remove torsional damper and crankcase front cover as outlined.
2. Remove camshaft timing chain as outlined.
3. Use tool J-1619 for crankshaft sprocket removal.

INSTALLATION

1. Use tool J-21058 for installation of crankshaft sprocket.
2. Install camshaft timing chain as outlined.
3. Install crankcase front cover and torsional damper as outlined.

CAMSHAFT BEARINGS

REMOVAL

Camshaft bearings can be replaced while engine is disassembled for overhaul or without complete disassembly. To replace bearings without complete disassembly, remove camshaft and crankshaft, leaving cylinder heads attached and pistons in place. Before removing crankshaft, tape threads of connecting rod bolts to prevent damage to crankshaft. Fasten connecting rod against sides of engine so that they will not interfere while replacing camshaft bearings.

1. With camshaft and crankshaft removed, drive camshaft rear plug from cylinder block.

   NOTE: This procedure is based on removal of bearings center of engine first, thus requiring a minimum amount of turns to remove all bearings.

2. Using tool set J-6098-01 (with nut and thrust washer installed to end of threads), position pilot in front camshaft bearing and install puller screw through pilot.

   NOTE: Tool adaptor J-6098-8 is used with tool set J-6098 for replacing cam bearings. Combination of above tools is tool set J-6098-01.

3. Install tool with shoulder toward bearing. Be sure a sufficient amount of threads are engaged.
4. Using 2 wrenches, hold puller screw while turning nut. (Figure 6) When bearing has been pulled from bore, remove tool and bearing from puller screw.
5. Remove remaining bearings (except front and rear) in same manner. It will be necessary to position pilot in rear camshaft bearing to remove rear intermediate bearing.

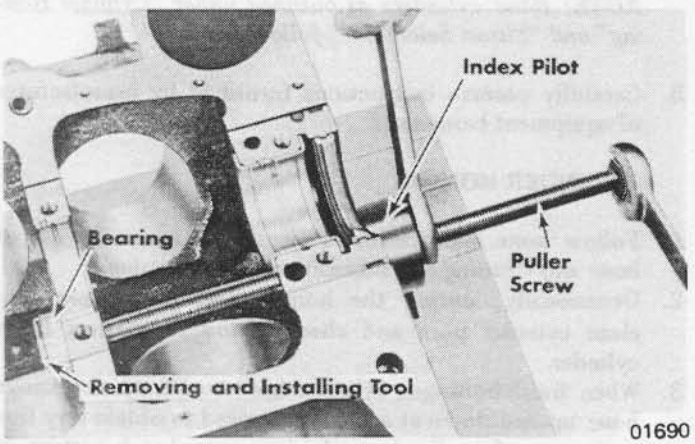


Figure 6. Replacing Camshaft Bearings

6. Assemble remover tool on driver handle and remove front and rear camshaft bearings by driving toward center of cylinder block. (Figure 7)

INSPECTION

With camshaft removed, inspect bearings for wear or damage and replace if necessary.

INSTALLATION

Install front and rear camshaft bearings first. These bearings act as guides for pilot and center the remaining bearings being pulled into place. Nos. 1-thru-4 cam bearing oil hole must be aligned with oil holes in cam bearing bore. No. 5 bearing bore is grooved, and cam bearing must be positioned at or near 6 o'clock position.

1. Assemble installer tool on driver handle and install front and rear camshaft bearings by driving toward center of cylinder block. (Figure 7)

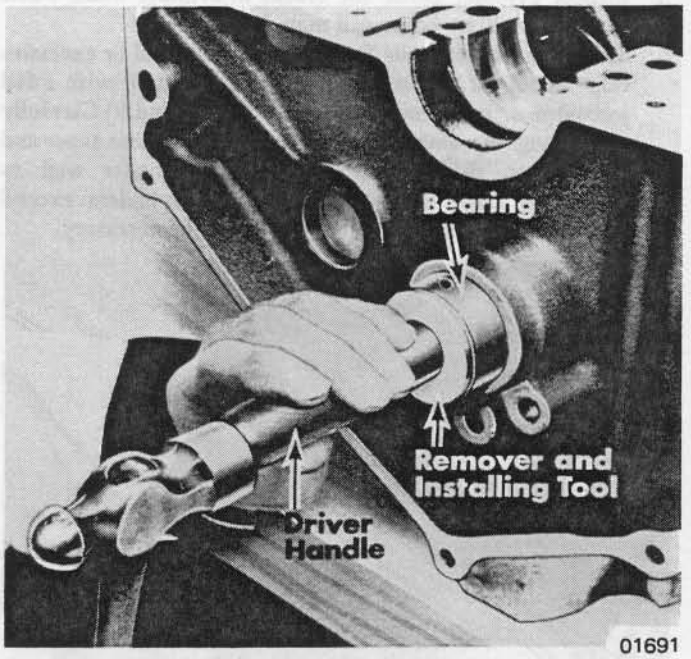


Figure 7. Replacing Rear Camshaft Bearing

CAUTION: Oil holes in bearings must line up with oil holes in cylinder block.

2. Position pilot in front camshaft bearing and install puller screw through pilot.
3. Position camshaft bearing in bore, then install installer tool on puller screw with shoulder toward bearing.
4. Using 2 wrenches, hold puller screw while turning nut. After bearing has been pulled into bore, remove tool from puller screw and check alignment of oil hole in camshaft bearing. (Figure 6)
5. Install remaining bearings in same manner. It will be necessary to position pilot in rear camshaft bearing to install rear intermediate bearing.
6. Install a new camshaft rear plug.

   NOTE: Install plug flush to 1/32" (.8mm) deep and parallel with rear surface of cylinder block.

CYLINDER BLOCK

CLEANING and INSPECTION

1. Remove all engine components as previously outlined.
2. Wash cylinder block thoroughly in cleaning solvent and clean all gasket surfaces.
3. Remove oil gallery plugs and clean all oil passages.

   NOTE: These plugs may be removed with a sharp punch, or they may be drilled and pried out.

4. Clean and inspect water passages in cylinder block.
5. Inspect cylinder block for cracks in cylinder walls, water jacket valve lifter bores and main bearing webs.
6. Measure cylinder walls for taper, out-of-round or excessive ridge at top of ring travel. This should be done with a dial indicator or inside micrometer. (Figure 8 and 9) Carefully work gauge up and down cylinder to determine taper and turn it to different points around cylinder wall to determine out-of-round condition. If cylinders exceed specifications, boring and/or honing will be necessary.

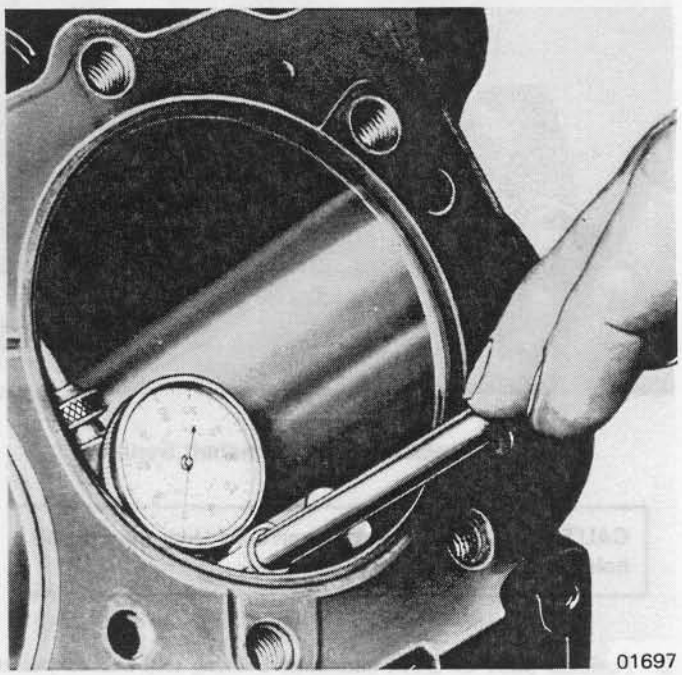
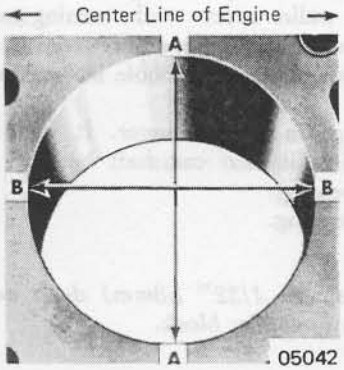


Figure 8. Measuring Cylinder Bore



"A" = At right angle to centerline of engine
"B" = Parallel to centerline of engine
"Out-of-round" = Difference between "A" and "B"
"Taper" = Difference between measurement "A" at top of cylinder bore and "A" measurement at bottom of cylinder bore.

Figure 9. Cylinder Measurement

REPAIRS

CYLINDER CONDITIONING

1. Performance of the following operation depends upon engine condition at time of repair.
2. If cylinder block inspection indicates that block is suitable for continued use (except for out-of-round or tapered cylinders), they can be conditioned by honing or boring.
3. If cylinders have less than .005" (.127mm) taper or wear, they can be conditioned with a hone and fitted with high limit standard size piston. A cylinder bore of less than .005" wear or taper may not clean up entirely when fitted to a high limit piston. To entirely clean up the bore, it will be necessary to rebore for an oversize piston. If more than .005" taper or wear, bore and hone to smallest oversize that will permit complete resurfacing of all cylinders.
4. When pistons are being fitted and honing is not necessary, cylinder bores may be cleaned with a hot water and detergent wash. After cleaning, swab cylinder bores several times with light engine oil and a clean cloth, then wipe with a clean dry cloth.

CYLINDER BORING

1. Before using any type boring bar, file off top of cylinder block to remove dirt or burrs. This is very important to prevent boring bar tilt, with result that rebored cylinder wall is not at right angles to crankshaft.
2. Measure piston to be fitted with a micrometer, measuring at center of piston skirt and at right angles to piston pin. Bore cylinder to same diameter as piston and hone to give specified clearance.

   NOTE: Hone cylinders as outlined under "Cylinder Honing" and "Piston Selection", following.

3. Carefully observe instructions furnished by manufacturer of equipment being used.

CYLINDER HONING

1. Follow hone manufacturer's recommendations for use of hone and cleaning and lubrication during honing.
2. Occasionally, during the honing operation, thoroughly clean cylinder bore and check piston for correct fit in cylinder.
3. When finish-honing a cylinder bore to fit a piston, move hone up-and-down at a sufficient speed to obtain very fine uniform surface finish marks in a cross-hatch pattern of approximately 30° to cylinder bore. Finish marks should be clean but not sharp, free from imbedded particles and torn or folded metal.
4. Permanently mark piston (for cylinder to which it has been fitted) and proceed to hone cylinders and fit remaining pistons.

CAUTION: Handle pistons with care and do not attempt to force them through cylinder until cylinder is honed to correct size, as this type piston can be distorted by careless handling.

5. Thoroughly clean cylinder bores with hot water and detergent. Scrub well with a stiff bristle brush and rinse thoroughly with hot water. It is extremely essential that a good cleaning operation be performed. If any abrasive material remains in cylinder bores, it will rapidly wear new rings and cylinder bores in addition to bearings lubricated by the contaminated oil. Swab bores several times with light engine oil on a clean cloth, then wipe with a clean dry cloth. Cylinder should not be cleaned with kerosene or gasoline. Clean remainder of cylinder block to remove excess material spread during honing operation.

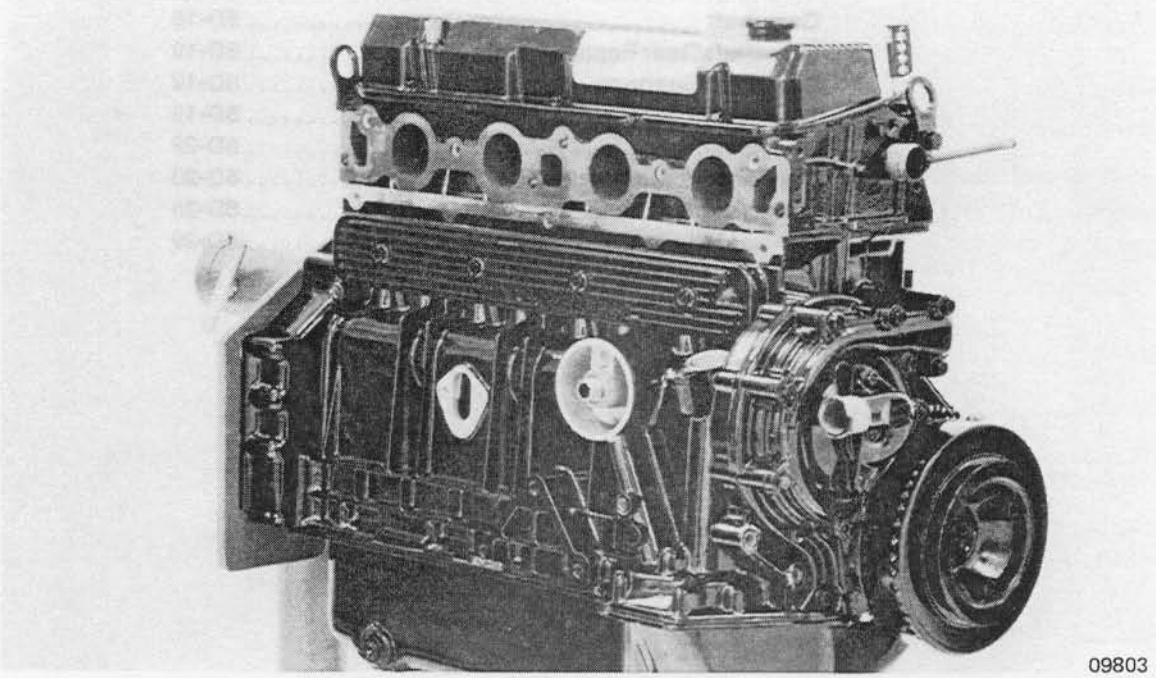
PISTON SELECTION

1. Check USED piston to cylinder bore clearance as follows:
   a. Measure "cylinder bore diameter" with a telescope gauge (2½" [63.5mm] from top of cylinder bore).
   b. Measure "piston diameter" (at skirt across center line of piston pin).
   c. Subtract piston diameter from cylinder bore diameter to determine "piston-to-bore clearance".
   d. Determine if "piston-to-bore clearance" is in acceptable range shown in "Specifications" Section 8.
2. If used piston is not satisfactory, determine if a new piston can be selected to fit cylinder bore within acceptable range.
3. If cylinder bore must be reconditioned, measure new piston diameter (across centerline of piston pin), then hone cylinder bore to correct clearance (preferable range).
4. Mark piston to identify cylinder for which it was fitted.

SECTION 5 - ENGINE

MERCRUISER

PART D - ENGINE MECHANICAL, 470 MODEL



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GENERAL

Some repairs, that are listed in this section, must be completed with engine removed from boat. Engine removal depends upon type of repair and boat design. Place engine on repair stand for major repairs.

All specifications are listed in Section 8. Lubricate all moving parts (during reassembly) with engine oil. Apply Perfect Seal on threads of and under head of cylinder head bolts and on threads of all cylinder block external bolts, screws and studs.

TOOLS

All "J" - prefix (special) tools* in this Section may be purchased from:

Kent-Moore, Inc.
28635 Mound Road
Warren, MI 48089

All "T" prefix (special) tools* herein may be purchased from:

Owatonna Tools, Inc.
Attn: Ford Order Desk
Owatonna, MN 55060

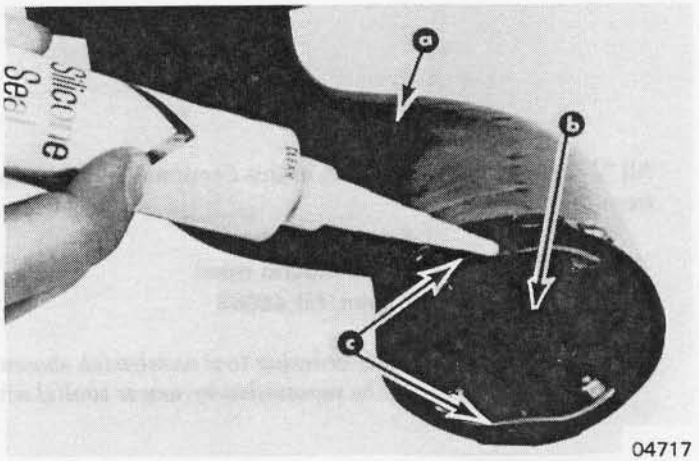
**If ordering tool number(s), shown in discussion on following pages, number(s) may be superseded by newer tool(s) which will be sent by tool manufacturer listed above.*

REMOVAL/DISASSEMBLY/CLEANING - INSPECTION REASSEMBLY/INSTALLATION

EXHAUST TUBE WATER SHUTTER

The engine is equipped with exhaust shutter in exhaust tube. Loose fit between shutter shaft and support brackets may make a rattling noise at idle speed. This noise can be corrected as follows:

1. Drain water from exhaust manifold and elbow.
2. Loosen hose clamps which fasten exhaust bellows to exhaust tube.
3. Remove exhaust elbow fastener nuts and remove elbow and bellows as an assembly. Scrape gasket material from manifold and elbow.
4. Thoroughly clean area between shutter support brackets and exhaust tube with cleaning solvent and small brush.
5. Fill entire area between support brackets and tube with Silicone Seal. (Figure 1) Allow sealant to cure for 24 hours.
6. Reinstall elbow (using new gasket) and connect bellows. Torque hose clamps to 35 to 38 in. lbs. (40 to 44kg-cm).



a - Exhaust Tube b - Shutter c - Shutter Support Brackets

Figure 1. Sealant Application

EXHAUST MANIFOLD

REMOVAL (Figure 2)

1. Drain engine coolant systems.
2. Disconnect wire from temperature sending unit (located on thermostat/distribution housing).
3. Disconnect all hoses and exhaust bellows from manifold assembly.
4. Drain engine oil and remove oil dipstick tube.
5. Support manifold and remove exhaust manifold fasteners. Remove manifold assembly and discard gasket.

DISASSEMBLY (Figure 2)

1. Remove closed cooling reservoir from thermostat/distribution housing and remove thermostat.
2. Remove thermostat/distribution housing from manifold body.
3. Remove temperature sender and brass plug from thermostat/distribution housing.
4. Remove exhaust elbow from manifold body.
5. Remove end cap from aft end of manifold body.

CLEANING and INSPECTION

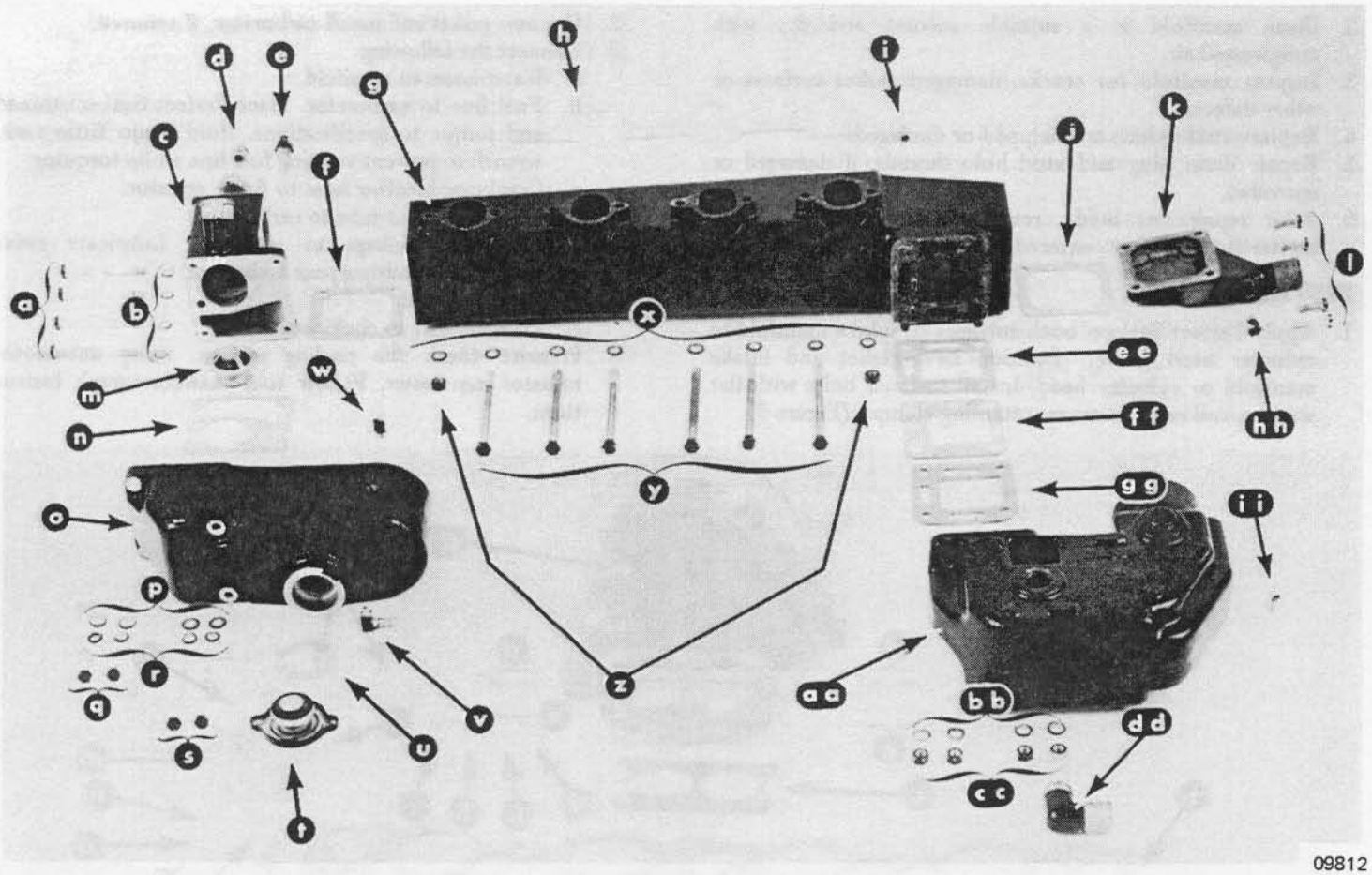
1. Clean gasket material from all surfaces and wash parts in solvent.
2. Inspect all parts carefully. Machined surfaces must be clean and free of all marks and deep scratches, or water and/or exhaust leaks may result.
3. Check water passages for sand, silt or other foreign material. Passages must be clean for efficient cooling.
4. If more thorough inspection is desired, pipe plugs may be removed from exhaust manifold and exhaust elbow.

REASSEMBLY (Figure 2)

1. Install new gasket and end cap on aft end of manifold body (with hose connector facing toward engine side of manifold).
2. Place new gasket, plate, second gasket and exhaust elbow onto manifold body, as shown in Figure 2. Install lockwasher and nuts. Torque nuts to specifications.
3. Apply Perfect Seal to threads and install temperature sender and brass plug.
4. Install new gasket, thermostat/distribution housing and attaching bolts, using copper washers.
5. Place thermostat into its cavity in housing. Install new gasket, closed cooling reservoir and attaching bolts with flat washers and lockwashers.

INSTALLATION

1. Using a new gasket, position manifold assembly onto cylinder head and install lockwashers, nuts and bolts. Torque fasteners to specifications.
2. Install dipstick tube to oil pan and to support clamp located on exhaust manifold fastener bolt.
3. Connect all hoses and exhaust bellows to manifold assembly. Tighten hose clamps securely.
4. Connect engine harness wire to temperature sender (located on thermostat/distribution housing).
5. Fill engine to proper oil level and closed cooling system to proper fluid level.
6. Pressure check the cooling system, using automotive radiator cap tester. Follow tool manufacturer's instructions.



a - Thermostat/Distribution Housing Bolts (4)
b - Copper Washers (4)
c - Thermostat-Distribution Housing
d - Brass Plug
e - Temperature Sender
f - Thermostat/Distribution Housing to Manifold Body Gasket
g - Manifold Body
h - Manifold Body to Cylinder Head Gasket
i - Drain Plug
j - End Cap to Manifold Body Gasket
k - End Cap
l - End Cap to Manifold Body Bolts (4)
m - Thermostat
n - Reservoir to Thermostat/Distribution Housing Gasket
o - Closed Cooling Reservoir
p - Flat Washers (4)
q - Reservoir to Thermostat/Distribution Housing Short Bolts (2)
r - Lockwashers (4)
s - Reservoir to Thermostat/Distrib. Housing Long Bolts (2)
t - Reservoir Cap
u - Reservoir Cap Gasket
v - Overflow Fitting
w - Bleed Hose Fitting
x - Lockwashers (8)
y - Manifold Body to Cylinder Head Bolts (6)
z - Manifold Body to Cylinder Head Nuts (2)
aa - Exhaust Elbow
bb - Lockwashers (4)
cc - Exhaust Elbow to Manifold Body Nuts (4)
dd - Hose Connector Elbow
ee - Manifold Body to Plate Gasket
ff - Plate
gg - Plate to Exhaust Elbow Gasket
hh - Bleed Hose Fitting
ii - Drain Plug

Figure 2. Exhaust Manifold Assembly

INTAKE MANIFOLD

REMOVAL

1. Disconnect the following:
   a. Wires from choke cover.
   b. Throttle cable.
   c. Carburetor linkage from manifold.
   d. Fuel pump vent tube from carburetor.
   e. Crankcase breather hose from flame arrestor.
   f. Fuel line from carburetor.
   g. Water hoses from manifold.
2. Support intake manifold and remove 7 manifold fasteners and engine harness retaining clamps. Remove manifold assembly and discard gasket.
3. Carburetor may be removed from intake manifold, if necessary.

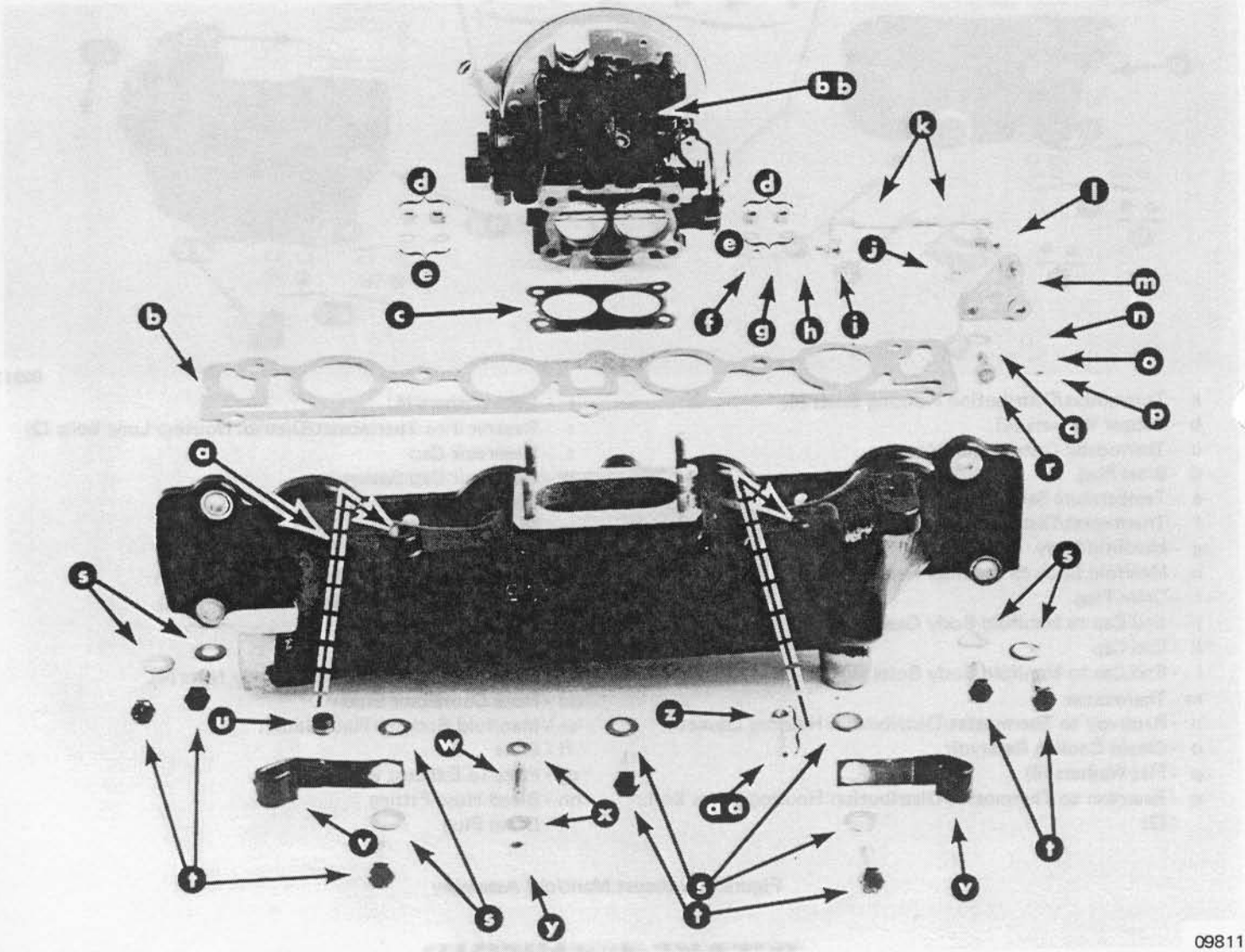
CLEANING and INSPECTION

1. Remove all gasket material from machined surfaces of manifold.

2. Clean manifold in a suitable solvent and dry with compressed air.
3. Inspect manifold for cracks, damaged gasket surfaces or other defects.
4. Replace studs which are stripped or damaged.
5. Repair drain plug and stud hole threads, if damaged or corroded.
6. After repairs are made, remove all filings and foreign matter that may have entered manifold.

INSTALLATION

1. Apply Perfect Seal on both surfaces of intake manifold to cylinder head gasket. Position new gasket and intake manifold to cylinder head. Install fastener bolts with flat washers and engine harness retaining clamps. (Figure 3)
2. Use new gasket and install carburetor, if removed.
3. Connect the following:
   a. Water hoses to manifold.
   b. Fuel line to carburetor. Place Perfect Seal on thread and torque to specifications. Hold banjo fitting with wrench to prevent twisting fuel line while torquing.
   c. Crankcase breather hose to flame arrestor.
   d. Fuel pump vent tube to carburetor.
   e. Carburetor linkage to manifold. Lubricate swivel points with Multipurpose Lubricant.
   f. Throttle cable.
   g. Connect wire to choke cover.
4. Pressure check the cooling system, using automotive radiator cap tester. Follow tool manufacturer's instructions.



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a - Manifold Assembly
b - Manifold to Cylinder Head Gasket
c - Carburetor to Manifold Gasket
d - Carburetor Mounting Nuts (4)
e - Washers (4)
f - Link Rod to Carburetor Swivel Nut
g - Small Washer
h - Large Washer
i - Link Rod to Carburetor Swivel
j - Washer
k - Link Rod
l - Link Rod to Throttle Lever Swivel
m - Throttle Lever
n - Large Washer
o - Small Washer
p - Link Rod to Throttle Lever Swivel Nut
q - Washer
r - Throttle Lever Fastening Bolt
s - Washers (9)
t - Manifold Fastening Bolts (7)
u - Plug
v - Engine Harness Retaining Clamps (2)
w - Throttle Cable Attaching Stud
x - Washers (2)
y - Nut
z - Set Nut
aa - Throttle Stop Screw
bb - Carburetor Assembly

Figure 3. Intake Manifold Assembly

ROCKER ARM COVER

REMOVAL

1. Remove spark plug high tension leads from their retainer.
2. Disconnect crankcase ventilation hose from rocker arm cover.
3. Remove attaching bolts.
4. Remove rocker arm cover and gasket.

CLEANING and INSPECTION

1. Wash cover in solvent and dry with compressed air.
2. Clean gasket surface on cover and cylinder head, using a scraper, then a degreaser.
3. Gasket surface must be free of deep scratches, or oil leaks may result.

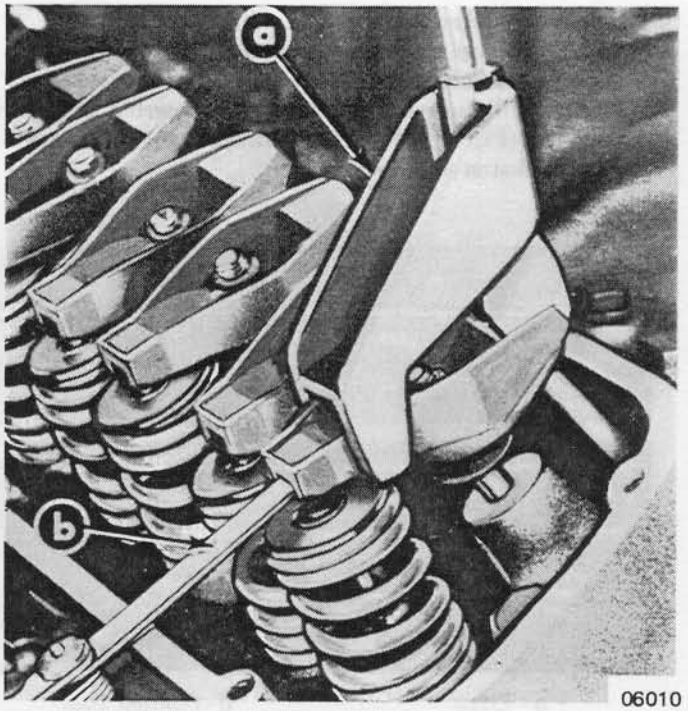
INSTALLATION

1. Use a new gasket and install rocker arm cover and torque to specifications.
2. Connect crankcase ventilation hose to rocker arm cover.
3. Place spark plug high tension leads into their retainer.

VALVE CLEARANCE

Valve clearance must be checked whenever valve face and/or seat is ground, valve stem ground, cylinder head and/or block mating surface is milled, or if a noise is present in valve train (which is not caused by collapsed hydraulic lifter). Use following procedure to check valve clearance (valves are not adjustable):

1. Remove rocker arm cover as outlined, preceding.
2. With valve closed (piston at TDC) and lifter fully collapsed (using special tool Part No. T711P-6513A), check clearance between rocker arm and valve stem. (Figure 4)
3. If clearance is not within specifications, check for worn parts in valve train. If parts are not worn, install push rod of correct length (see Parts Manual) to bring valve clearance within specifications. (See Section 8 for specifications.)



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a - Tool
b - Feeler Gauge

Figure 4. Checking Valve Clearance

VALVE MECHANISM

REMOVAL

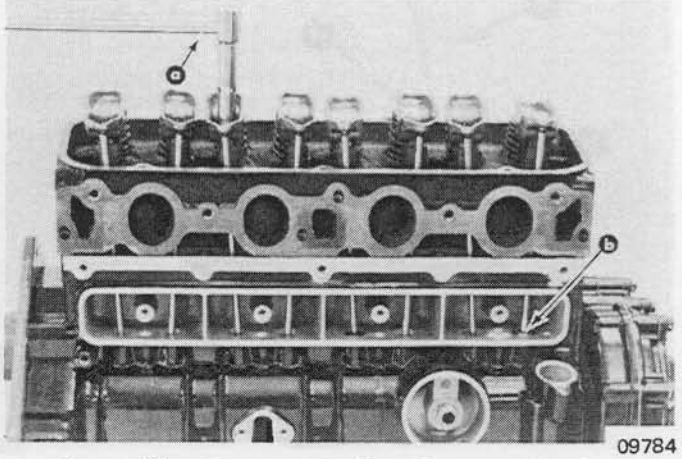
1. Remove rocker arm cover as outlined, preceding.

   IMPORTANT: Place rocker arms, rocker arm fulcrums and push rods in a rack so that they may be reinstalled in same location.

2. Remove rocker arm bolts, fulcrums, rocker arms and push rods.

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air.
2. Inspect each rocker arm for wear in area where push rod, valve stem and fulcrum contact rocker arm. Replace excessively worn rocker arms.
3. Check push rod ends and fulcrum for excessive wear. Replace badly worn parts.
4. Check push rods for bent condition.



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a - Torque Wrench b - Push Rods in Lifter Socket

Figure 5. Valve Mechanism Installation

INSTALLATION

1. Install push rods. Be sure that push rods seat in lifter socket. (Figure 5)
2. Lubricate fulcrums and rocker arms with Moly-Kote (C-92-55049) or Engine Oil Supplement (C-92-63283). Install rocker arms, fulcrums and rocker arm fastening bolts. DO NOT tighten bolts at this time.

   NOTE: Torquing of rocker arm bolts (Step 3) and checking valve clearance (preceding) are both done with valve in closed position. Time can be saved by completing both of these steps at the same time.

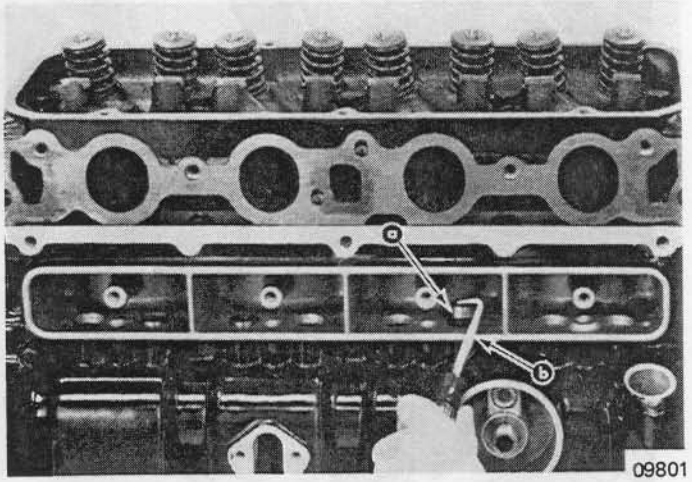
CAUTION: Push rods may become bent, if the following rocker arm torque procedure is not completed.

3. With piston at TDC, torque rocker arm bolts (Figure 5) for that cylinder to specifications. Turn engine crankshaft for proper piston position for each cylinder and torque all rocker arm bolts to specifications.
4. Install rocker arm cover as outlined, preceding.

HYDRAULIC VALVE LIFTERS

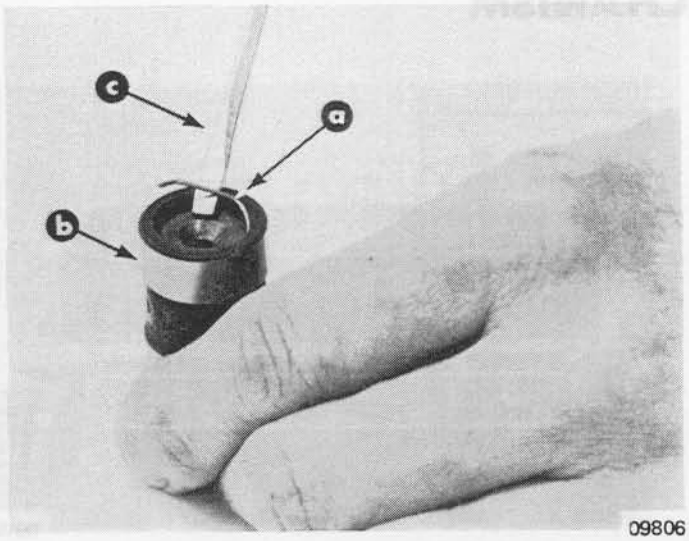
REMOVAL

1. Remove rocker arm cover as outlined, preceding.
2. Remove valve mechanism, preceding.
3. Remove 4 bolts with "O" rings and remove side cover.
4. Lift out lifters with a pointed tool inserted in lock ring groove. (Figure 6) Place lifters in order so that lifter will be reinstalled in same location.



a - Lifter b - Pointed Tool

Figure 6. Removing Hydraulic Valve Lifters



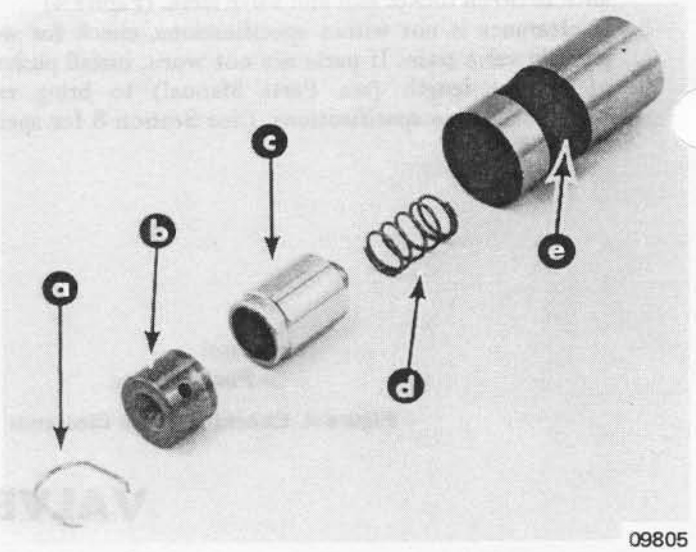
a - Lockring b - Lifter Assembly c - Small Screwdriver

Figure 7. Removing Lockring

DISASSEMBLY

NOTE: Lifters can be disassembled, cleaned and reinstalled. If any parts are worn, lifter must be replaced as an assembly.

1. Use small screwdriver or needle-nose pliers to remove lockring. (Figure 7)
2. Lightly tap top end of lifter assembly on flat surface to remove push rod cup, plunger/check valve assembly and spring. (Figure 8)



a - Lockring
b - Push Rod Cup
c - Plunger/Check Valve Assembly
d - Plunger Spring
e - Lifter Body

Figure 8. Lifter Components

CLEANING and INSPECTION

1. Thoroughly clean all parts in cleaning solvent and dry them with compressed air.
2. Carefully inspect all parts for wear, pitting, scoring or galling. If any parts are damaged or worn, entire lifter assembly must be replaced. If outside of lifter body is scuffed or worn, inspect cylinder block lifter bore. If bottom of lifter is scuffed or worn, inspect camshaft lob
   If push rod seat is scuffed or worn, inspect push rod.

REASSEMBLY

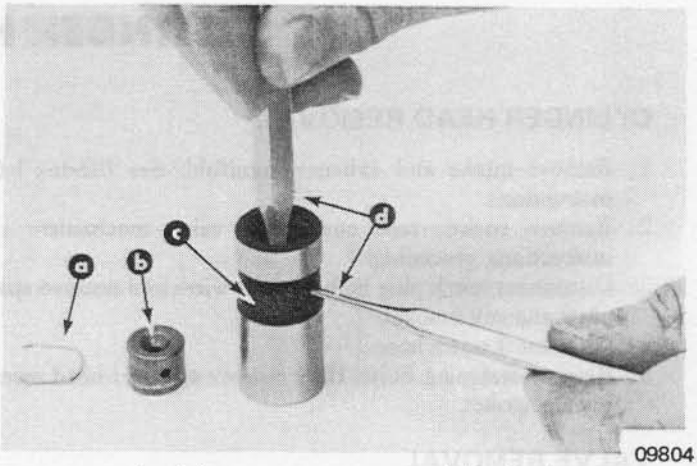
IMPORTANT: Work in clean area.

1. Inject engine oil in lifter body to approximately ½-full.

2. Set plunger spring in lifter body. (Figure 8)
3. Place plunger assembly (check valve end down) in lifter body. (Figure 8)
4. Use small punch to unseat check ball (located in bottom of plunger assembly) and push plunger (compressing spring) until top of plunger is below hole in side of lifter body. (Figure 9) Now insert small punch through side hole to hold plunger in position.
5. Remove punch from check ball and position push rod cup in lifter body.
6. Install lockring in groove and remove punch from lifter body side hole.

INSTALLATION

1. Lubricate all camshaft lobes, lifter bores and entire lifter with Moly-Kote or Engine Oil Supplement.
2. Replace lifter into lifter bore from which it was removed.
3. Install valve mechanism as outlined, preceding.
4. Remove all oil from cylinder block side cover gasket surface. Install cover, using new gasket and new "O" rings on cover attaching bolts.
5. Install rocker arm cover as outlined, preceding.



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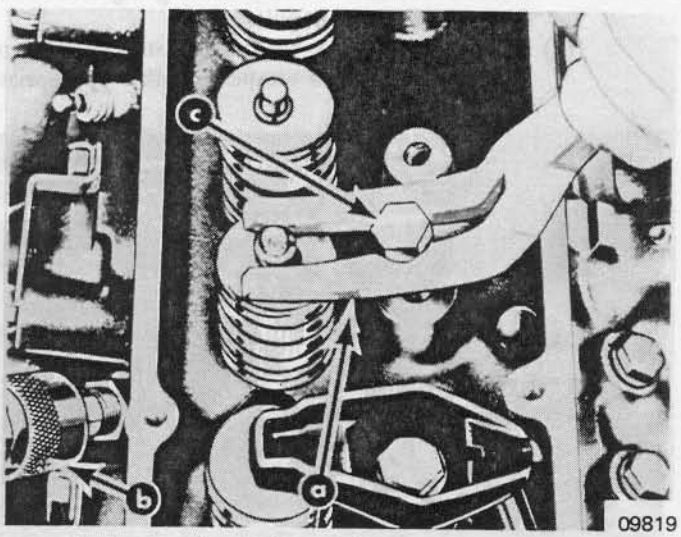
a - Lockring
b - Push Rod Cup
c - Lifter Body
d - Small Punches

Figure 9. Assembling Lifter

VALVE SPRING, RETAINER or STEM SEAL REPLACEMENT (with CYLINDER HEAD INSTALLED)

1. Remove rocker arm cover as outlined (see "Index").
2. Remove spark plug of cylinder(s) from which valve spring will be removed.
3. Remove rocker arm bolt, fulcrum, rocker arm and push rod of applicable valve(s).
4. Position piston of applicable cylinder at top dead center to prevent valve from dropping out of valve guide.
5. Install an air line with adaptor in spark plug hole (Figure 10) and turn on air pressure.
6. Install suitable bolt (from where rocker arm bolt was removed) and position compressor tool as shown in Figure 10. Compress valve spring and remove retainer locks. Remove tool, then remove retainer, valve spring and seal. (Figure 11)
7. Install new valve stem seal. Place spring in position over valve and install valve spring retainer. Compress valve spring and install spring retainer locks. (Figure 10) Remove compressor tool and bolt.

   NOTE: If new spring was installed, check installed spring height. Refer to "Valve Spring Inspection" (see "Index").
8. Remove air line and adaptor. Install spark plug and wire.
9. Install valve mechanism as outlined (see "Index").
10. Install rocker arm cover as outlined (see "Index").



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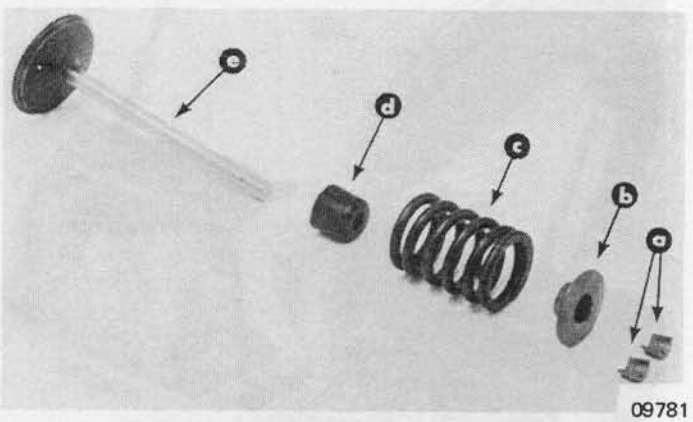
a - Tool
b - Air Line Adaptor
c - Suitable Bolt

Figure 10. Compressing Valve Spring



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a - Retainer Locks
b - Spring Retainer
c - Valve Spring
d - Seal
e - Valve

Figure 11. Valve and Related Parts

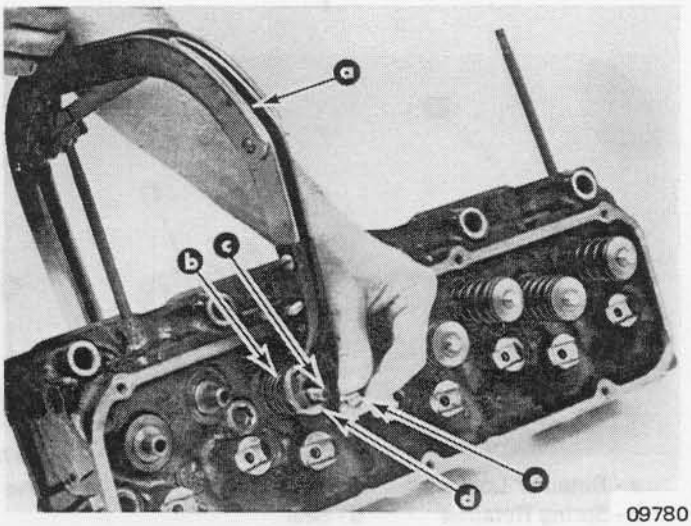
CYLINDER HEAD and VALVES

CYLINDER HEAD REMOVAL

1. Remove intake and exhaust manifold. See "Index" for instructions.
2. Remove rocker arm cover and valve mechanism per instructions, preceding.
3. Disconnect spark plug high tension wires and remove spark plugs and coil bracket.
4. Disconnect water hose.
5. Remove fastening bolts, then remove cylinder head assembly and gasket.

VALVE REMOVAL

1. Remove cylinder head as outlined, preceding.
2. Clean carbon out of cylinder head combustion chambers before removing valves (to prevent damaging valve seats). Refer to "Cleaning and Inspection", following.
3. Compress valve springs (Figure 12) with conventional valve spring compressor and remove retainer locks.
4. Remove spring compressor tool, spring retainer, valve spring, valve stem seal and valve. Identify all valves to reinstall in same location.
5. Repeat Steps 3 and 4 (above) to remove each valve.

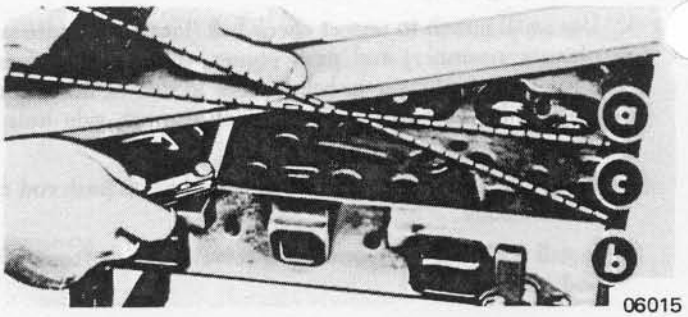


a - Valve Spring Compressor Tool
b - Valve Spring
c - Valve Stem
d - Spring Retainer
e - Retainer Locks

Figure 12. Removing and/or Installing Valves

CYLINDER HEAD CLEANING, INSPECTION and RECONDITIONING

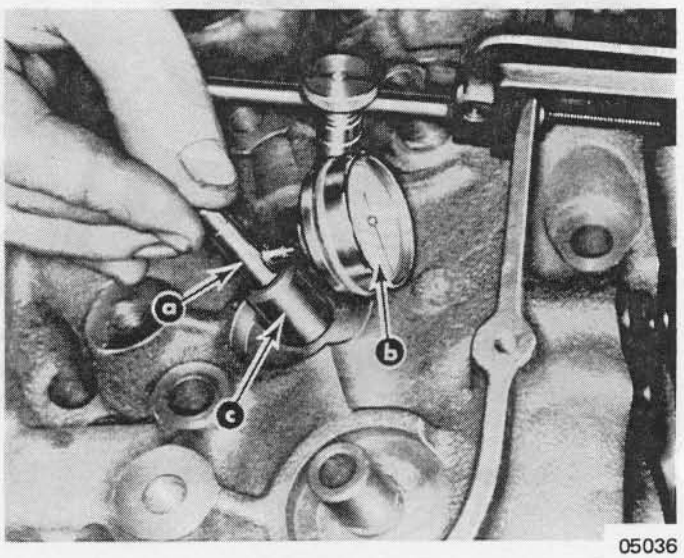
1. With valves installed to protect valve seats, remove deposits from combusion chambers and valve heads with a scraper and wire brush.
2. Clean cylinder head gasket surfaces with a scraper.
3. After removing valves, clean valve guide bores with valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits.
4. Clean all bolt holes.
5. Check cylinder head for cracks and inspect gasket surface for burrs and nicks. Replace head if cracked.
6. Check cylinder head for flat gasket surface (Figure 13), particularly if cylinder head was removed because of gasket leaks. (See "Specifications" Section 8.) If necessary to refinish cylinder head gasket surface, do not plane or grind off more than .010" (0.25mm).



a - Check Diagonally
b - Check Diagonally
c - Check Across Center

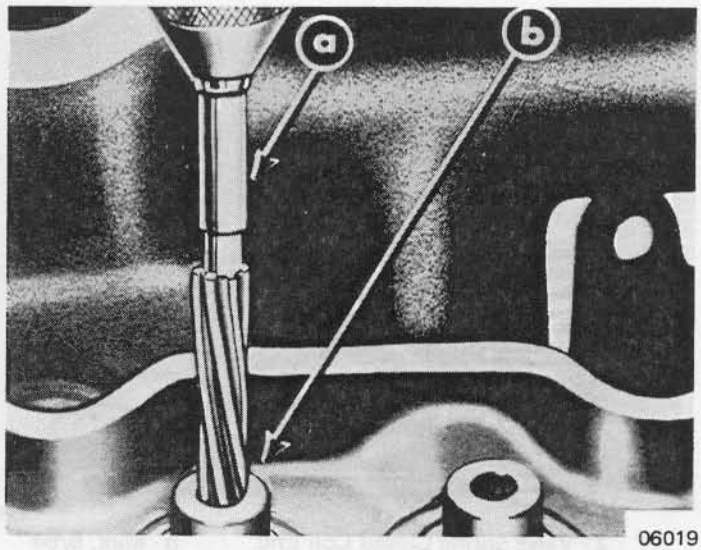
Figure 13. Typical Cylinder Head Flatness

7. Measure valve stem clearance (Figure 14) as follows:
   a. Clamp dial indicator on one side of cylinder head rocker arm cover gasket rail, locating indicator so that movement of valve stem from side-to-side (crosswise to head) will cause direct movement of indicator stem. Indicator stem must contact side of valve stem just above valve guide. (Figure 14)
   b. With valve head dropped about 1/16" (1.6mm) off valve seat, move valve stem from side-to-side, using light pressure to obtain clearance reading.
   c. If clearance exceeds specifications, it will be necessary to ream valve guides for next oversize valve(s), as follows (Figure 15):
      (1) Valve guide(s) to be reamed must be refinished before doing any checking or refacing of valve seat.
      (2) After guide is refinished, seat also must be refaced to match guide.
      (3) Always use reamers in sequence (starting with smallest oversize reamer) when going from standard valve stem to an oversize.
      (4) Remove sharp corner (inside diameter) from top of valve guide, using a scraper or other appropriate tool.



a - Valve Stem
b - Dial Indicator
c - Valve Guide

Figure 14. Checking Valve Stem Clearance

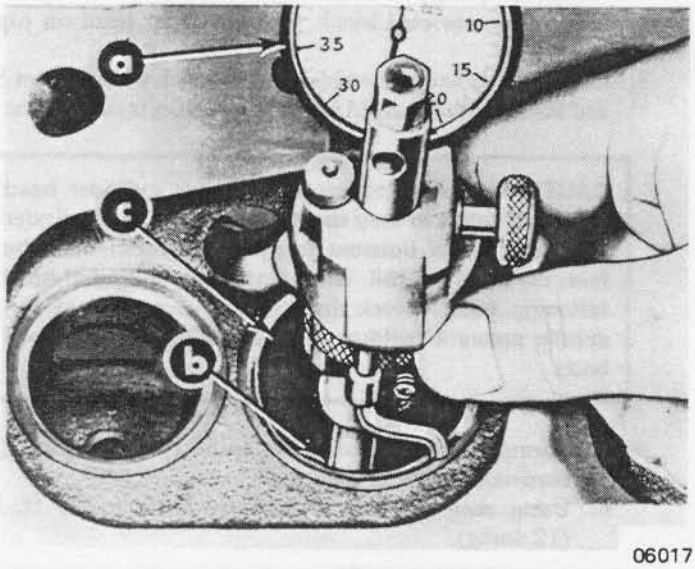


a - Reamer b - Valve Guide

Figure 15. Reaming Valve Guides

(5) Clean head assembly thoroughly to be sure that all metal filings are removed.

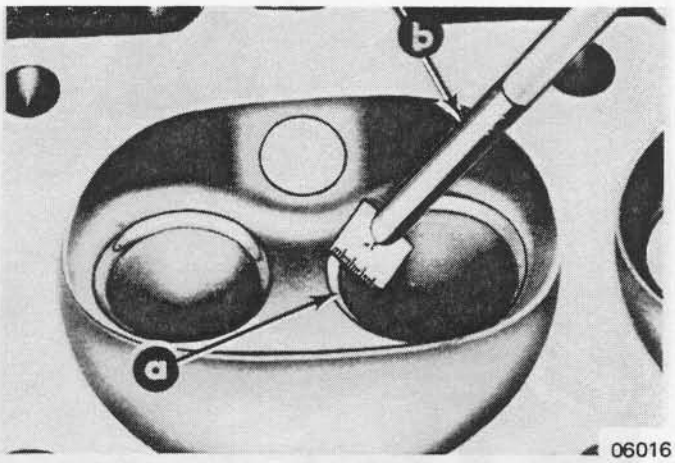
8. Check valve seat for runout (Figure 16), as follows:
   a. Install accurate gauge on tool positioned in valve stem guide.
   b. Follow instructions of gauge manufacturer. If runout exceeds wear limit, reface valve and valve seat. Refer to Step 9-b (following) for valve seat refacing.



a - Gauge b - Valve Stem Guide (Hidden) c - Valve Seat

Figure 16. Checking Valve Seat Runout

9. Check valve seat width (Figure 17), as follows:
   a. Use scale with small increments and measure valve seat width. (Figure 17)
   b. Reface valve seat(s), if width is not within specifications, as follows (Figure 18):
      (1) Closely coordinate refacing valve seat with refacing valve face so that finished seat and valve face are concentric, and specified interference fit will be maintained. This is important so that valve and seat have compression-tight fit. Be sure that refacer grinding wheels are properly dressed.
      (2) Grind valve seats to correct angle (see "Specifications" Section 8). Remove only enough stock to clean up pits and grooves or to correct valve seat runout.
      (3) Finished valve seat must contact appropriate center of valve face. Apply ink (with felt tip pen) to refinished valve face. Install valve and rotate with light pressure. Remove valve and check seat contact. If seat contacts center of valve face, contact is satisfactory. If seat contact is at top edge of valve face, lower the valve seat, using 30° angle grinding wheel. If seat contact is at bottom edge of valve face, raise the valve seat, using 60° angle wheel.
      (4) After seat has been refaced, recheck seat width. If width exceeds maximum limit, remove enough stock from top edge (use 30° wheel) and/or bottom edge (use 60° wheel) of seat to reduce width to specifications.



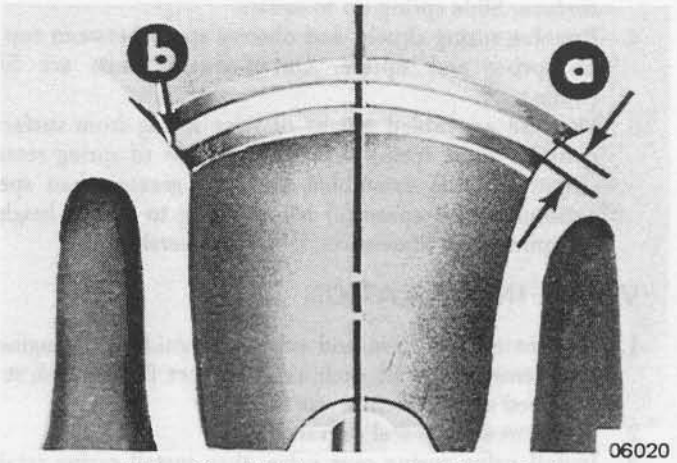
a - Valve Seat b - Scale

Figure 17. Checking Valve Seat Width

(5) If valve and/or seat has been refaced, check clearance between rocker arm seat and valve stem. Refer to "Valve Clearance" (see "Index").

VALVE CLEANING, INSPECTION and RECONDITIONING

1. Clean deposits from valve head and stem, being careful not to damage valve face.
2. Closely coordinate valve refacing operation with valve seat refacing operations so that finished angles of valve face and



a - Valve Seat Width b - Valve Angle

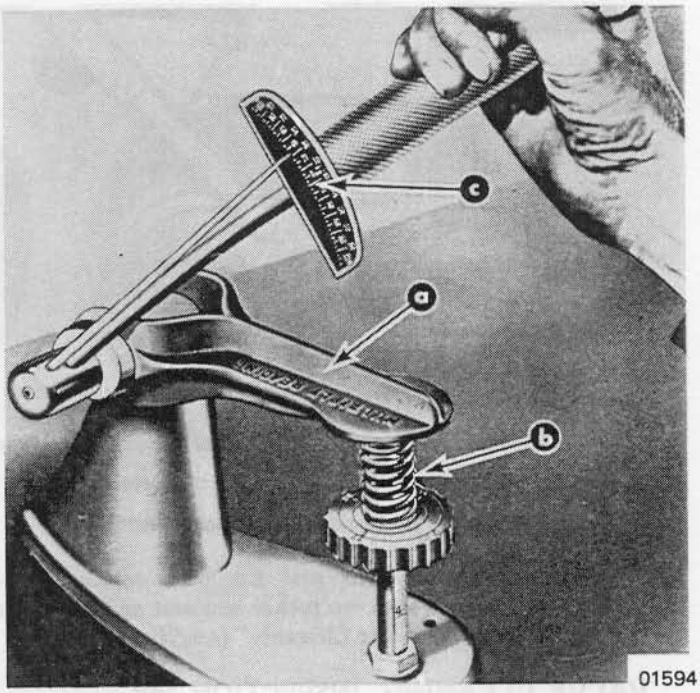
Figure 18. Refacing Valve Seat

valve seat will meet specifications and provide compression-tight fit. Be sure that refacer grinding wheels are properly dressed.

3. See Section 8, "Specifications", for valve face angle. Remove only enough stock to correct runout or to clean up pits and grooves. If edge of valve head is less than 1/32" (0.8mm) thick after grinding, replace valve.
4. If valve and/or seat has been refaced, check clearance between rocker arm seat and valve stem. Refer to "Valve Clearance" (see "Index").

VALVE SPRING INSPECTION

1. Check springs for correct pressure at specified spring lengths with Tool J-8056. (Figure 19) Follow tool manufacturer instructions.
2. Replace any spring not within specifications.



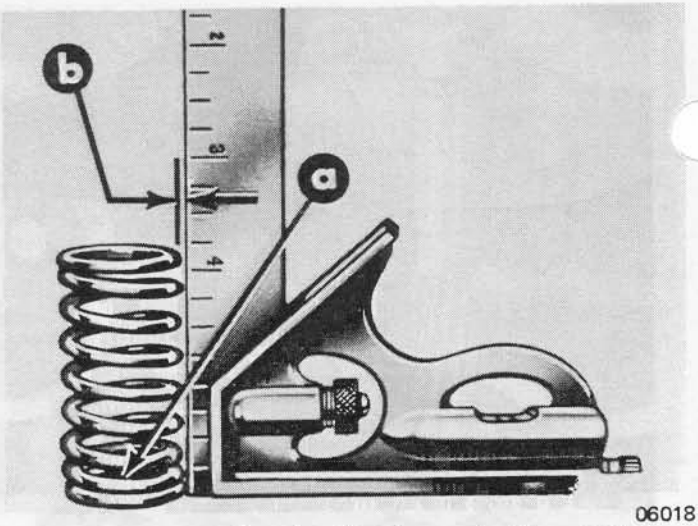
a - Valve Spring Pressure Tool b - Valve Spring
c - Torque Wrench

Figure 19. Checking Valve Spring Pressure

3. Check each spring for "square". Stand spring (closed coil end downward) and steel square (Figure 20) on flat surface. Slide spring up to square.
4. Revolve spring slowly and observe space between top coil of spring and square. Out-of-square limits are 5/64" (2mm).
5. Measure assembled height of valve spring from surface of cylinder head spring seat to underside of spring retainer. (Figure 21) If assembled height is greater than specifications, install spacer(s) below spring to reduce height to recommended dimension. DO NOT overshim.

VALVE INSTALLATION

1. Lubricate valve stem and valve stem guide with Engine Oil Supplement. Install each valve in port from which it was removed or to which it was fitted.
2. Install new stem seal on valve.
3. Install valve spring over valve, then install spring retainer. (Figure 11, preceding)
4. Compress spring (using compressor tool) and install retainer locks. (Figure 12, preceding) Make sure that locks are positioned properly in valve stem groove.



a - Valve Spring Closed Coil End b - Max. 5/64"

Figure 20. Checking Valve Spring Squareness

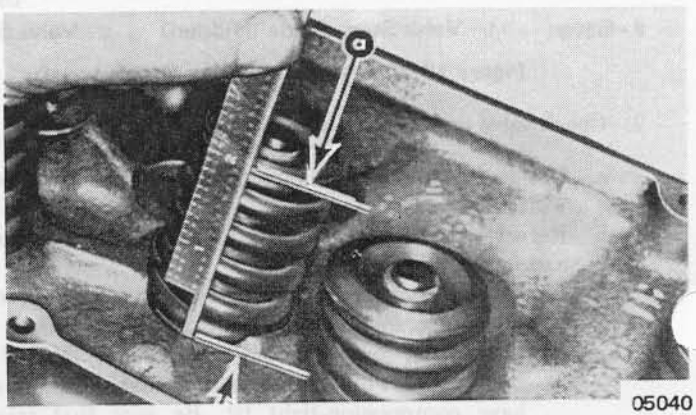
5. Measure valve spring assembled height. Refer to "Valve Spring Inspection", preceding.

CYLINDER HEAD INSTALLATION

1. Be sure that all gasket surfaces are clean.
2. Position cylinder head gasket on cylinder block with word "FRONT" (stamped on gasket) toward front of engine and facing down toward block. Place cylinder head on top of gasket.
3. Coat threads and underside of bolt head with Perfect Seal and install cylinder head bolts. Torque bolts as follows:

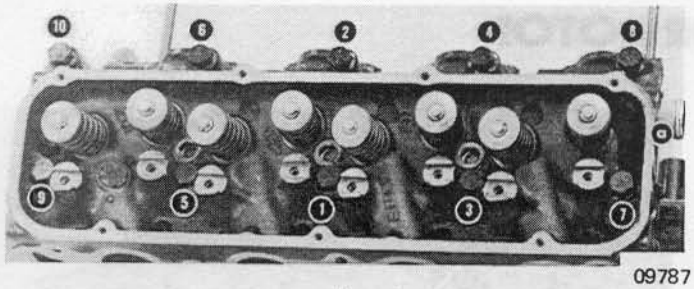
CAUTION: Failure to properly torque cylinder head bolts will result in very short head gasket life. Cylinder head bolt holes (located in cylinder block) must be free of water or oil when installing cylinder head fastening bolts. Block failure may occur from hydraulic pressure buildup while torquing cylinder head bolts.

a. Torque cylinder head bolts to 55 ft. lbs. (7.6mkg) in sequence shown in Figure 22.
b. Using same sequence, retorque bolts to 90 ft. lbs. (12.4mkg).



a - See Specifications

Figure 21. Measuring Spring Height



a - Front

Figure 22. Cylinder Head Torquing Sequence

c. Using same sequence, retorque bolts to 130 ft. lbs. (18mkg).

d. After engine has reached maximum operating temperature retorque cylinder head bolts to 130 ft. lbs., using same sequence.

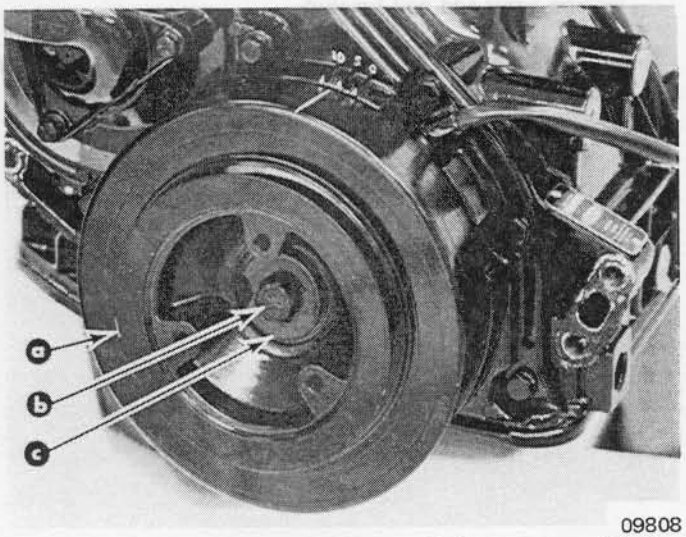
4. Connect water hose, install spark plugs, spark plug high tension wires and coil bracket.

5. Install valve mechanism, rocker arm cover, intake and exhaust manifolds (see "Index").

ALTERNATOR ROTOR

REMOVAL

1. Remove front engine mount assembly (if applicable).
2. Remove bolt from center of rotor (Figure 1) and remove washer from bolt.



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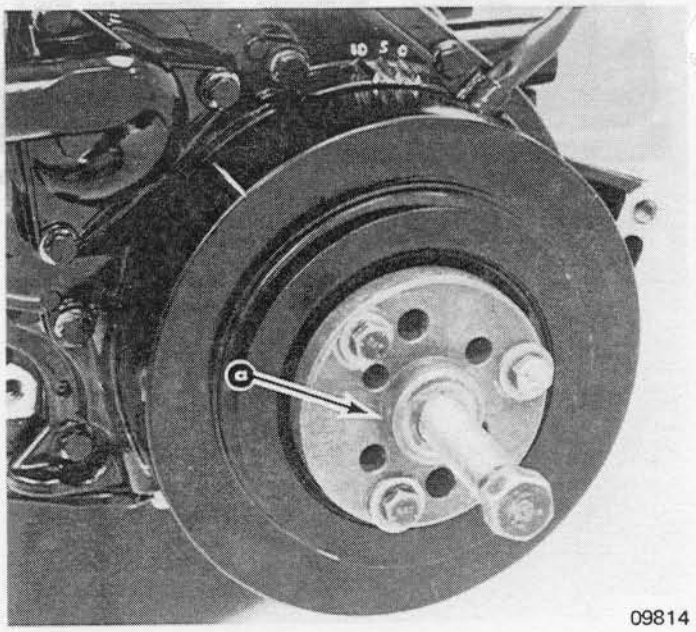
a - Alternator Rotor b - Center Bolt c - Washer

Figure 1. Alternator Rotor

3. Install Tool J-6978-04 and remove rotor assembly. (Figure 2) Use grease on tapered end of tool.

INSTALLATION

1. Lubricate lip of oil seal and rotor surface (where oil seal rides) with Multipurpose Lubricant.
2. Check that rotor locating key is properly installed in crankshaft groove.
3. Lubricate crankshaft end and inside diameter of rotor assembly with Chicago Manufacturing and Distribution Co. anti-scoring, extreme pressure Lubricant No. 3 or equivalent.
4. Position rotor assembly onto crankshaft, aligning key slot in rotor with key located on crankshaft.
5. Install Tool J-21058-8 into crankshaft end. Hold tool center shaft from turning and turn large nut to install rotor (Figure 3) until rotor bottoms out.
6. Install rotor fastening bolt and washer and torque bolt to specifications.



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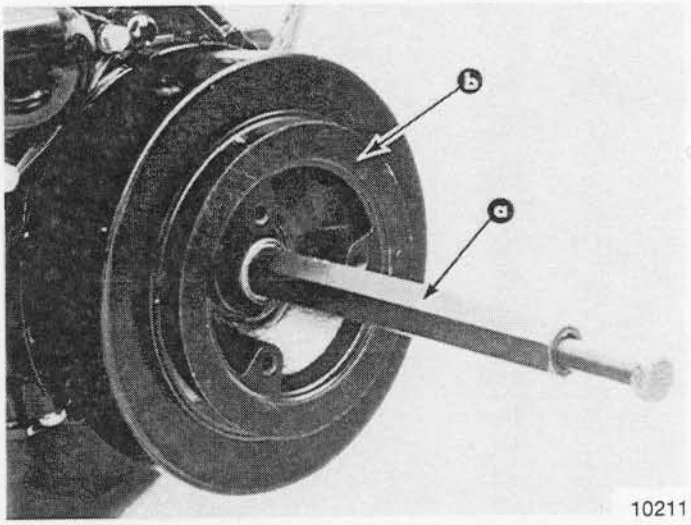
a - Tool

Figure 2. Removing Alternator Rotor



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a - Alternator Rotor b - Installation Tool

Figure 3. Installation of Alternator Rotor

STATOR

TESTING

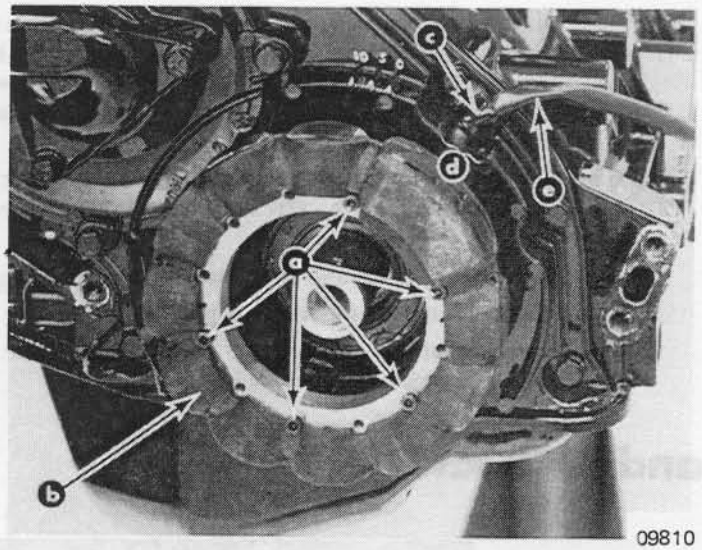
Refer to Section 3C,"Alternator".

REMOVAL

1. Remove alternator rotor as outlined, preceding.
2. Disconnect stator electrical wires from rectifier and remove stator wire harness from clamp. (Figure 4)
3. Remove 5 stator fastening screws and remove stator. (Figure 4)

INSTALLATION

1. Position stator onto front cover with output wires toward recess cast in cover. (Figure 10)
2. Apply Perfect Seal on screw threads, install screws (Figure 4) and torque to specifications.
3. Install stator wire harness in clamp and reconnect stator electrical wires to rectifier. (See Section 3E for proper electrical connections.)
4. Install alternator rotor as outlined, preceding.



a - Stator Fastening Screws
b - Stator Assembly
c - Wire Harness Clamp
d - Front Cover Recess
e - Stator Wire Harness

Figure 4. Stator Assembly on Engine

FRONT COVER and/or WATER PUMP SHAFT and FRONT COVER OIL SEALS

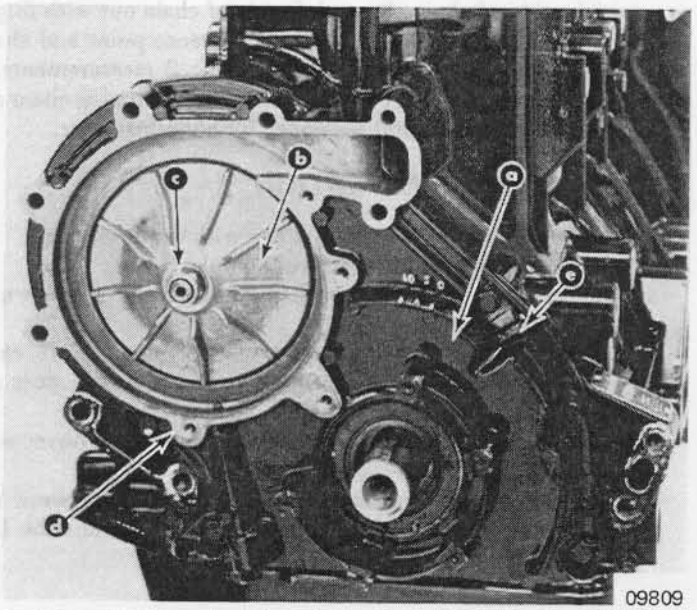
REMOVAL

IMPORTANT: Oil pan gasket must be replaced whenever front cover is removed. (Refer to "Oil Pan Removal-Installation".)

1. Remove front engine mount (if applicable).
2. Remove alternator rotor and stator as outlined, preceding.
3. Remove water pump impeller cover and pump impeller. (Figure 5) Impeller nut is left-hand thread.
4. Remove remaining front cover fastening bolts and cover.
5. Drive out both oil seals.

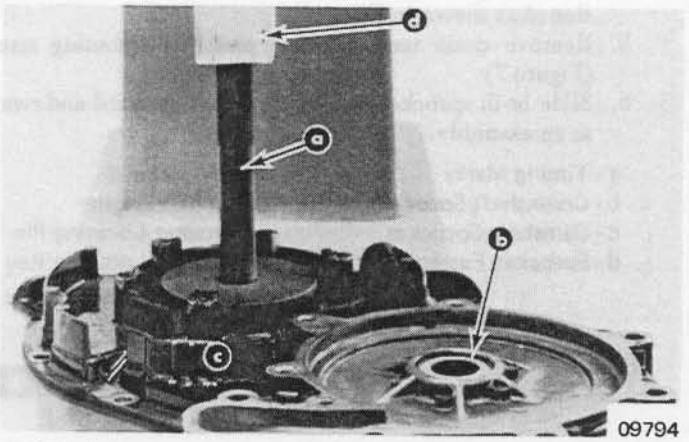
CLEANING and INSPECTION

1. Clean gasket surface of cover and cylinder block with a scraper.



a - Front Cover
b - Water Pump Impeller
c - Impeller Nut
d - Impeller Cover Gasket Mating Surface
e - "J" Clamp

Figure 5. Removing or Installing Front Cover



a - Tool
b - Water Pump Shaft Oil Seals
c - Front Cover Assembly
d - Arbor Press

Figure 6. Typical Oil Seal Installation

2. Clean parts in solvent and dry with compressed air. If oil seals are not being replaced, DO NOT allow solvent to remain on oil seals for any length of time.
3. Inspect oil seals for wear, tears, roughness and proper spring position. If oil seal serviceability is doubtful, replace oil seals.
4. Inspect surface of shaft(s) where oil seal lips contact shaft. Any groove in shaft in this area requires oil seal(s) and shaft replacement.

INSTALLATION

1. Apply Perfect Seal to outside diameter of water pump shaft oil seals and front cover oil seal. DO NOT allow sealer on lip of seals.

   IMPORTANT: Support underside of cover when installing oil seals.

2. Both water pump seal lips face water side or front of engine. First water pump seal is pressed in until it bottoms out; second seal is pressed in until even with cover surface. (Figure 6)

3. Fill space between water pump oil seals with Multipurpose Lubricant.
4. Install front cover crankshaft seal with seal lip facing in or toward engine block. Press seal in until it bottoms-out.
5. Lubricate seal lip with Multipurpose Lubricant.
6. Lubricate crankshaft end and water pump shaft with Multipurpose.
7. Position new front cover gasket over dowel pin on front of cylinder block.
8. Position front cover over gasket. Apply Perfect Seal on threads of front cover fastening bolts and install bolts. Torque bolts to specifications. "J" clamp location is shown in Figure 5.
9. Install water pump impeller, flat washer against impeller and onto larger diameter of shaft (use grease to hold washer in place), cupped washer (concave side toward impeller) and nut. (Figure 5) Torque left hand thread nut to specifications.
10. Install water pump cover, using new gasket. Apply Perfect Seal to fastening bolts' threads and torque to specifications.
11. Install alternator rotor and stator as outlined, preceding.
12. Reinstall front engine mount (if applicable).
13. Make sure that oil pan gasket has been replaced per instructions, preceding. (See "Index".)

TIMING CHAIN and SPROCKETS

REMOVAL

1. Drain cooling system and crankcase.
2. Remove alternator rotor, stator and front cover as outlined, preceding. (See "Index".)
3. Check timing chain deflection. Refer to "Timing Chain Deflection", following.
4. Crank engine until timing marks on sprockets are positioned as shown in Figure 7.
5. Remove chain tensioner and camshaft fastening screws. (Figure 7)
6. Slide both sprockets and timing chain forward and remove as an assembly.

a - Timing Marks
b - Crankshaft Sprocket
c - Camshaft Sprocket
d - Sprocket Fastening Screws
e - Timing Chain
f - Chain Tensioner
g - Sprocket Locating Pin
h - Sprocket Locating Key

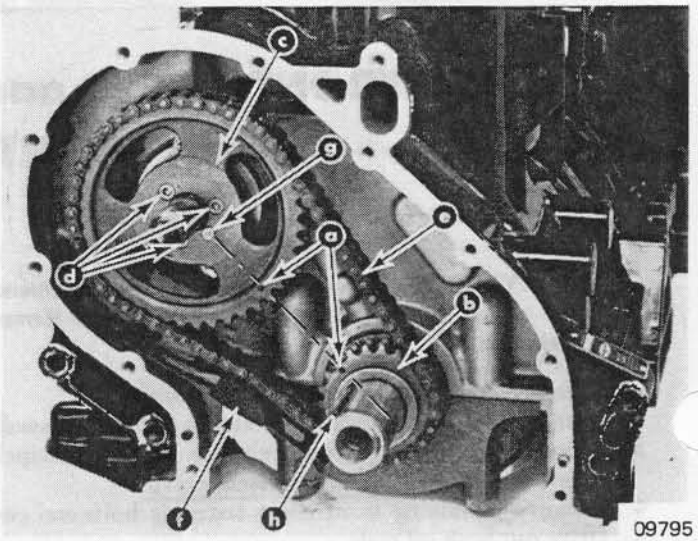


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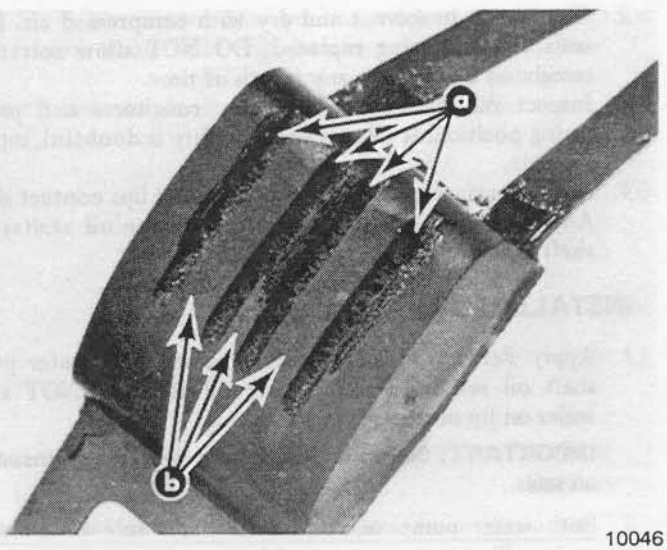
Figure 7. Timing Chain and Sprockets

TIMING CHAIN DEFLECTION

1. Rotate crankshaft in clockwise direction (as viewed from front) to take up slack on left side of chain.
2. Establish a reference point on cylinder block and measure from this point to chain.



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a - Normal Groove Wear
b - Excessive Wear Area

Figure 8. Chain Tensioner Wear

3. Rotate crankshaft in opposite direction to take up slack on right side of chain. Force left side of chain out with fingers and measure distance between reference point and chain. Deflection is difference between the 2 measurements. If deflection exceeds 1" (25.4mm), replace timing chain and inspect sprockets and tensioner for abnormal wear.

CLEANING and INSPECTION

1. Clean all parts in solvent and dry with compressed air.
2. Inspect chain for worn or broken links.
3. Inspect sprockets for cracks, scores, nicks and worn or damaged teeth.
4. Inspect chain tensioner for wear or damage. If chain deflection is within specifications and tensioner does not touch chain, replace tensioner.
5. Tensioner, that is worn beyond normal groove wear (Figure 8), must be replaced.
6. Place tensioner on flat surface. Demension between flat surface and top (highest point) of tensioner must be 1¼" (32mm) or higher.

INSTALLATION

1. Position crankshaft and camshaft with locating pin and key facing as shown in Figure 13.

2. Position sprockets in timing chain and simultaneously install sprockets (with chain) on camshaft and crankshaft. Timing marks must be located as shown in Figure 7. Check timing mark location, using a straight edge.
3. Install camshaft fastening screws and torque to specifications.
4. Install chain tensioner. Liberally lubricate chain, chain tensioner and sprockets with engine oil.
5. Install front cover, stator and alternator rotor as outlined, preceding. (See "Index".)
6. Fill cooling system and crankcase to proper levels.

ENGINE COUPLER and/or FLYWHEEL

REMOVAL

1. Remove engine from boat. (Refer to Section 2.)
2. Remove all attaching parts from flywheel housing and remove flywheel housing.
3. Remove coupler by disconnecting retaining nuts and washers.
4. Remove flywheel.

INSPECTION

Engine Coupling

1. Check coupling spline for wear. Coupling wear is caused by insufficient lubrication at time of installation.
2. Inspect hub bond. Bonding, that shears or pulls loose from hub center, indicates engine/drive misalignment.

Flywheel

Inspect ring gear for worn, chipped or cracked teeth. If teeth are damaged, replace flywheel.

INSTALLATION

1. Position flywheel (aligning offset holes) on crankshaft studs.
2. Position engine coupler on studs in same manner and install washers and locknuts. Torque nuts to specifications with torque wrench and Adaptor (C-91-35547).
3. Install flywheel housing and housing attaching parts.
4. Lubricate coupler splines with Multipurpose Lubricant and install engine in boat. (Refer to Section 2.)

OIL PAN

REMOVAL

1. Drain crankcase oil.
2. Remove oil level dipstick and dipstick tube.
3. Remove attaching bolts and washers and remove oil pan.

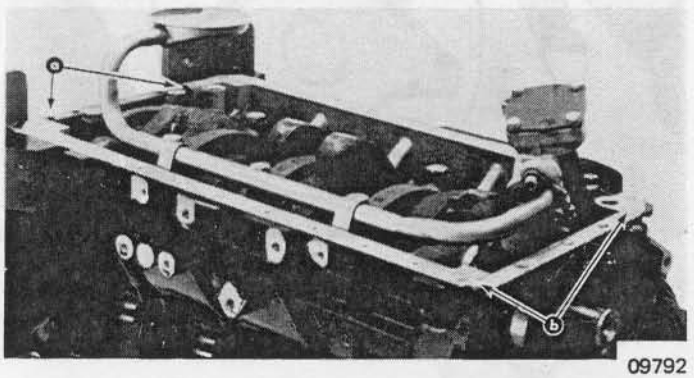
CLEANING and INSPECTION

1. Remove any dirt or metal particles from inside of pan.
2. Scrape all gasket material from gasket surface.
3. Wash pan in solvent and dry thoroughly.
4. Check pan for cracks, holes, damaged drain plug threads and damaged gasket surface.
5. Repair any damage or replace pan if repairs cannot be made.

INSTALLATION

IMPORTANT: Timing cover must be installed before installation of oil pan.

1. Coat cleaned gasket surfaces of block and oil pan with thin coat of Perfect Seal. Apply sealer thicker in area on block where timing cover meets block and on rear main cap seals. (Figure 9)
2. Position new gasket on cylinder block gasket surface.
3. Carefully position oil pan and install attaching bolts. Torque bolts to specifications from center outward in each direction. Retorque bolts a second time.



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a - Rear Main Cap Seals b - Timing Cover Mating Surface

Figure 9. Oil Pan Installation

OIL PUMP

REMOVAL

1. Remove oil pan as outlined, preceding.
2. Remove bolts from oil pump pickup tube clamps.
3. Remove oil pump attaching bolts and remove oil pump assembly.

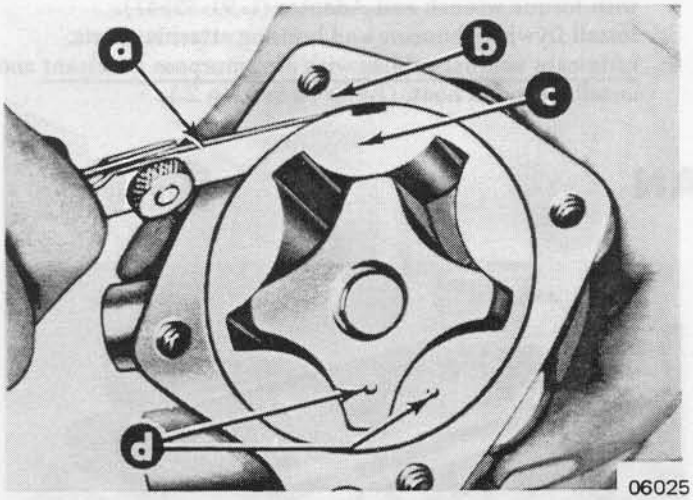
DISASSEMBLY

1. Remove 2 bolts and pickup tube, retaining flange and "O" ring.
2. Remove 4 screws and lockwasher and remove cover from pump body.

3. Inner and outer rotors each have identification marks on one side. After installation, these 2 points must appear on the same side. Remove inner and outer rotor.
4. Remove welch plug, spring and valve.

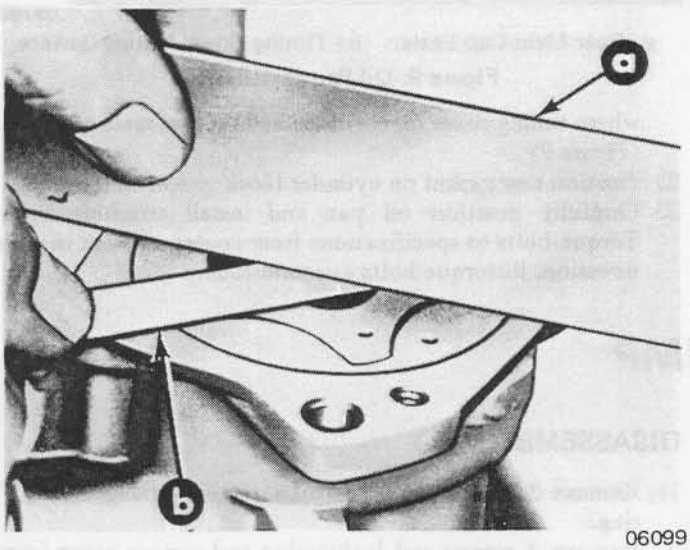
CLEANING and INSPECTION

1. Wash all parts in solvent. Clean inside of pump housing and pressure relief valve chamber with a brush. Be sure that all dirt and metal particles are removed. Dry parts thoroughly with compressed air.
2. Check inside of pump housing, outer rotor and inner rotor for damage or excessive wear.
3. Replace cover if rotor mating surface on cover is worn, scored or grooved.
4. Measure outer race to housing clearance [min. .001" to .0125" (.025mm to .318mm)]. (Figure 10)
5. With rotor assembly installed in pump housing, place a straight edge over rotor assembly and pump body. (Figure 11) Use a feeler gauge and measure clearance (rotor end play) between straight edge and rotor [min. .001" to max. .005" (.025mm to .127mm)].
6. Check drive shaft to pump housing clearance by measuring



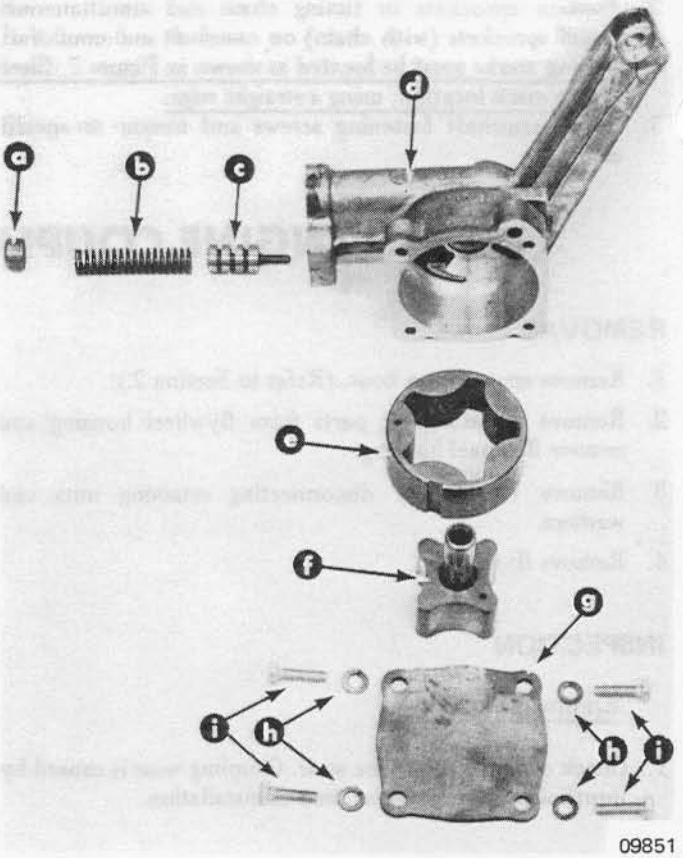
a - Feeler Gauge
b - Housing
c - Outer Race
d - Identification Marks

Figure 10. Checking Outer Rotor to Housing Clearance



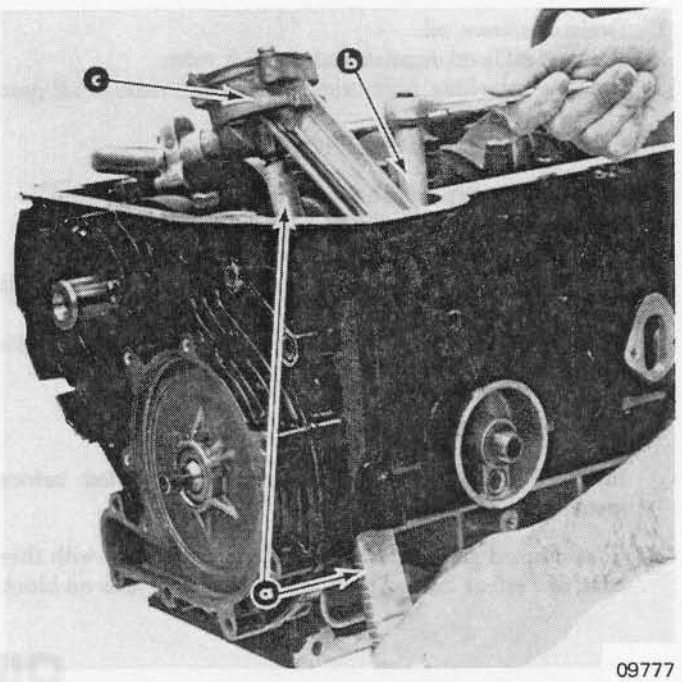
a - Straight Edge
b - Feeler Gauge

Figure 11. Checking Rotor End Play



a - Welch Plug
b - Relief Valve Spring
c - Relief Valve Plunger
d - Pump Housing
e - Outer Rotor
f - Inner Rotor
g - Cover
h - Lockwasher (4)
i - Screw (4)

Figure 12. Oil Pump Assembly



a - Oil Pump Alignment Tool
b - Tightening Pump Fastening Bolts
c - Oil Pump

Figure 13. Installing Oil Pump Assembly

OD of shaft and ID of housing cavity [min. .0015" to max. .0025" (.038mm to .064mm)].

7. Inspect relief valve piston for scores and free operation in bore.

8. Inspect relief valve spring for collapsed or damaged condition.

REASSEMBLY

Oil pump assembly is shown in Figure 12.

1. Oil all parts thoroughly.
2. Install oil pressure relief valve plunger, spring and new welch plug. Plug should be installed flush with pump housing.
3. Install outer and inner rotor and shaft assembly. Be sure that dot (identification mark) on outer and inner rotor is facing the same direction.
4. Install cover and torque cover attaching screws to specifications.
5. Position "O" ring and install pickup tube, its retaining flange (flat surface against pump housing) and 2 fastening bolts. Torque bolts to specifications.

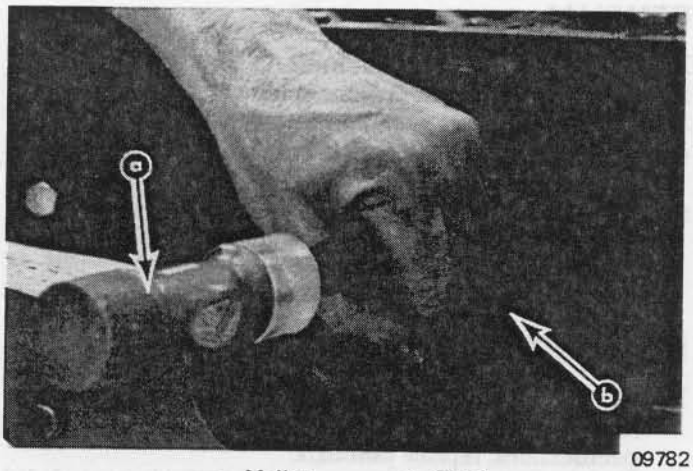
INSTALLATION

1. Position oil pump onto cylinder block and loosely install fastening bolts.
2. Install Oil Pump Alignment Tool (C-91-75691) thru distributor installation hole and into oil pump drive. (Figure 13)
3. Torque oil pump fastening bolts to specifications.
4. Fasten oil pump pickup tube to cylinder block in 2 places, using clamps and fastening screws. Coat threads with Perfect Seal and torque screws to specifications.
5. Install oil pan as outlined, preceding.

OIL SEAL (REAR MAIN)

REMOVAL

1. Remove flywheel, using instructions, preceding.
2. Pry old oil seal from cylinder block assembly, using appropriate tool. Take care that crankshaft seal surface is not scratched or damaged by tool.



a - Mallet b - Tool

Figure 14. Installing Rear Main Oil Seal

CLEANING and INSPECTION

1. Clean oil seal cavity in cylinder block.
2. Inspect area on crankshaft (where oil seal rides) for groove, nicks or pitting condition. If necessary, clean up crankshaft surface with No. 320 grit polishing cloth and engine oil. Replace crankshaft if damage is too great. Too much surface removed from crankshaft seal surface will cause oil leak.
3. Always install new oil whenever engine is disassembled. DO NOT reinstall used seals.

INSTALLATION

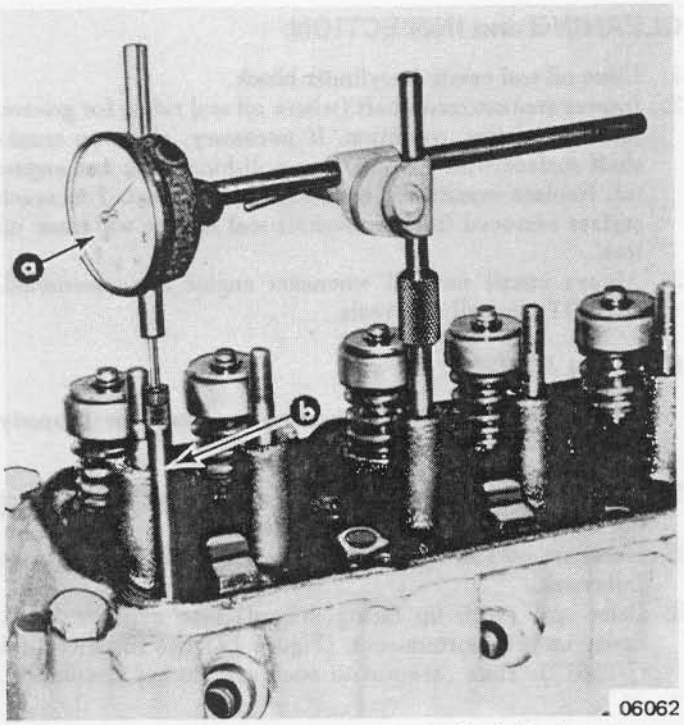
IMPORTANT: Rear main bearing cap must be properly installed before installation of oil seal.

1. Apply Perfect Seal to rear oil seal housing. Sealant must not be applied on crankshaft seal surface.
2. Lubricate oil seal lip and crank surface with Multipurpose Lubricant.
3. Drive seal (with lip facing inward) into cylinder block cavity until it bottoms-out. (Figure 14) Use Installer Tool (J-26817). Take care not to cock seal during installation.

MEASURING LOBE LIFT

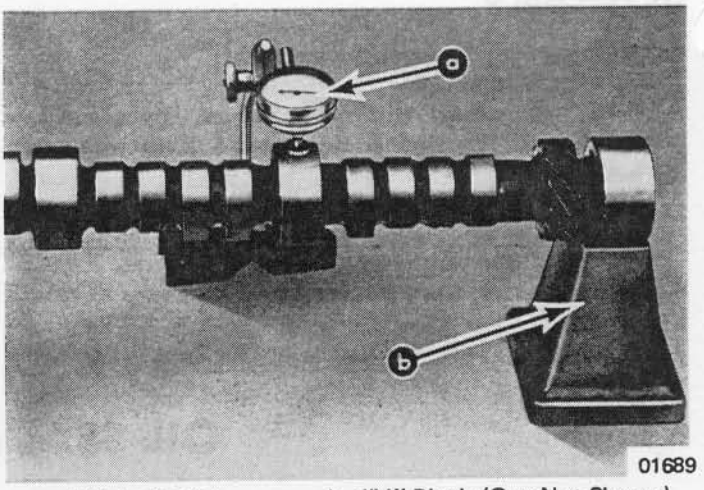
NOTE: Procedure is similar to checking valve timing. If improper valve operation is indicated, measure lift of each push rod in consecutive order and record the readings.

1. Remove valve mechanism as outlined.
2. Position indicator point on push rod. (Figure 1)
3. Rotate crankshaft slowly in direction of rotation until lifter is on lowest position of cam lobe.
4. Set dial indicator on zero, then rotate crankshaft slowly until push rod is in fully-raised position.
5. Compare total lift recorded from dial indicator with specifications in Section 8.
6. Continue to rotate crankshaft until indicator reads zero (0). This will be a check on accuracy of original indicator reading.



a - Dial Indicator b - Push Rod

Figure 1. Measuring Camshaft Lobe Lift (Typical Cylinder Head)



a - Dial Indicator b - "V" Block (One Not Shown)

Figure 2. Checking Camshaft Alignment

7. If camshaft readings for all lobes are within specifications, remove dial indicator assembly.
8. Install and adjust valve mechanism as outlined.

REMOVAL

1. Remove valve lifters as outlined.
2. Remove engine front cover as indicated.
3. Remove fuel pump as outlined.
4. Align timing gear marks, then remove timing chain and sprockets, as explained.
5. Pull camshaft out thru front of block.

NOTE: Support camshaft carefully when removing to protect camshaft bearing surface.

INSPECTION

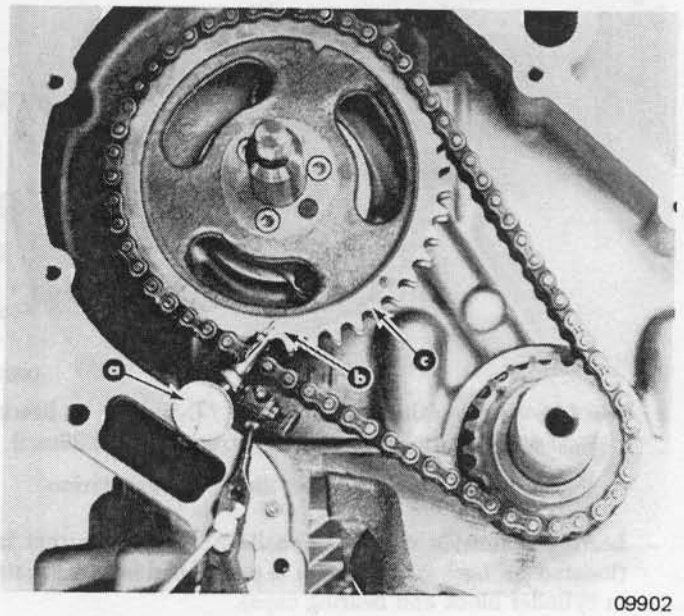
1. Measure camshaft bearing journals with a micrometer for out-of-round condition. If journals exceed out-of-round specifications, replace camshaft.
2. Check camshaft for alignment with "V" blocks and dial indicator (Figure 2) for exact amount that camshaft is out-of-true. If out more than .002" (.051mm) on dial indicator, replace camshaft.
3. Inspect camshaft sprocket and thrust plate for wear or damage. Measure camshaft end play. (Figure 3, following)

CAMSHAFT GEAR REPLACEMENT

Refer to "Timing Chain and Sprockets" (see "Index").

INSTALLATION

1. Install camshaft in engine block, being careful not to damage camshaft bearing surface or camshaft. Install thrust plate and torque screws to specifications.
2. Install timing chain and sprockets as outlined (see "Index").
3. With sprockets and timing chain properly installed, check camshaft end play. Use dial indicator on face of camshaft sprocket (Figure 3) and move camshaft in-and-out while recording end play. If not within specifications, replace thrust plate and/or sprocket.
4. Install fuel pump as outlined.
5. Install engine front cover as explained.
6. Install valve lifters as outlined.



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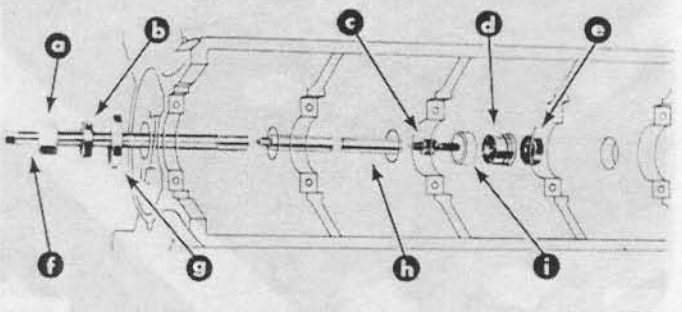
a - Dial Indicator b - Indicator Registering Point
c - Camshaft Sprocket

Figure 3. Checking Camshaft End Play

CAMSHAFT BEARINGS

Camshaft rotates directly in aluminum (cylinder block) bores. If bore surface is damaged, bore can be enlarged 2.2495" to 2.2510" (57.137mm to 57.175mm) diameter and bearings can be installed. Refer to Parts Manual for bearings. If one bore surface is damaged, all bores should be enlarged and bearings installed. Bearing Installation Kit (T65L-6250-A) should be used. Typical installation is shown in Figure 4. Hole in bearing must align with hole in block. Follow tool manufacturer's installation instructions.



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a - Pulling Nut
b - Thrust Bearing
c - Expanding Mandrel
d - Expanding Collet
e - Backup Nut
f - Puller Screw
g - Puller Plate
h - Puller Screw Extension
i - Camshaft Bearing

Figure 4. Typical Camshaft Bearing Installation

CRANKSHAFT

Crankshaft can be removed while engine is disassembled for overhaul or without complete disassembly.

REMOVAL

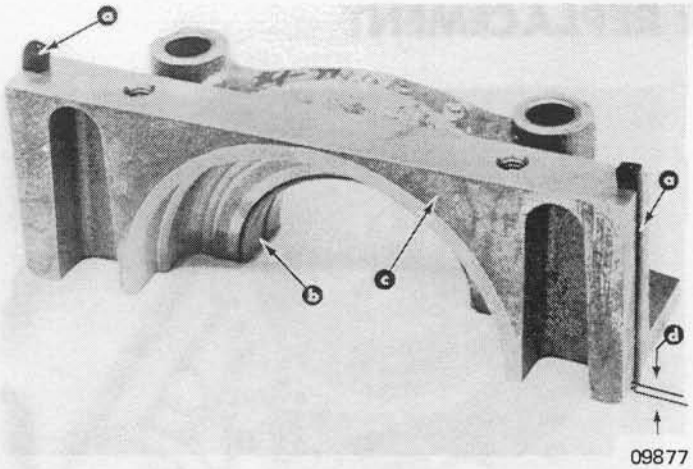
1. Remove flywheel housing, coupler and flywheel.
2. Remove spark plugs.
3. Remove oil pan and oil pump.
4. Remove front cover and timing chain.
5. Check connecting rod caps for cylinder number identification. If necessary, mark caps.
6. Remove connecting rod caps and push pistons to top of bores.
7. Remove main bearing caps and rear main oil seal and lift crankshaft out of cylinder block.
8. Remove main bearings from cylinder block and main bearing caps.

CLEANING and INSPECTION

1. Wash crankshaft in solvent and dry with compressed air.
2. Measure dimensions of main bearing journals and crankpins with a micrometer for out-of-round, taper or undersize (see "Specifications" Section 8).
3. Check crankshaft for run-out by supporting at front and rear main bearing journals in "V" blocks and check at front and rear intermediate journals with a dial indicator (see "Specifications").
4. Replace or recondition crankshaft if not within specifications.

INSTALLATION

1. Check bearing clearance as outlined, following.
2. Install bearings in cylinder block and main bearing caps, then lubricate bearing surface with engine oil. Thrust

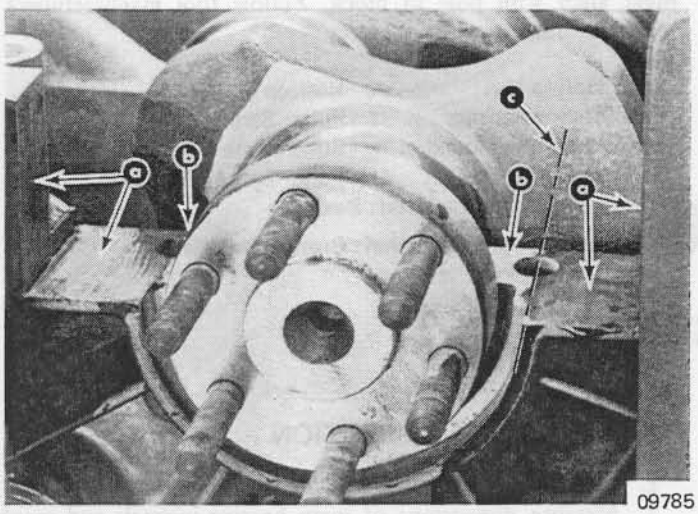


a - Rear Main Bearing Cap Side Oil Seals (2) b - Bearing
c - Rear Main Bearing Cap d - Protrude .015" (.38mm)

Figure 5. Rear Main Bearing Side Seal Installation

bearing is located at No. 3 position. Make sure that tab (located on back of bearings) is positioned in slot (located in cylinder block and bearing caps).

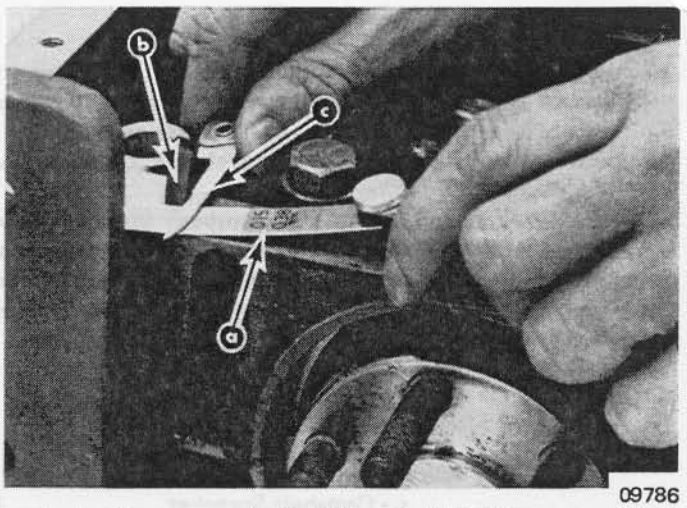
3. Stretch rear main side oil seal slightly and install in groove on each side of rear main. (Figure 5) Seal end must protrude .015" (0.38mm) from block side of bearing cap. Leave ample amount of seal extend from bottom (oil pan side) of bearing cap which will be cut to .015" protrusion after bearing cap installation.
4. Apply Perfect Seal to cylinder block in area where rear main bearing cap mates with block. DO NOT apply sealer beyond centerline of bolt holes toward crankshaft. (Figure 6)



a - Area on Which Sealer Is Applied
b - Area to Which Sealer Is NOT Applied (One Side Hidden)
c - Bolt Hole Centerline (One Each Side)

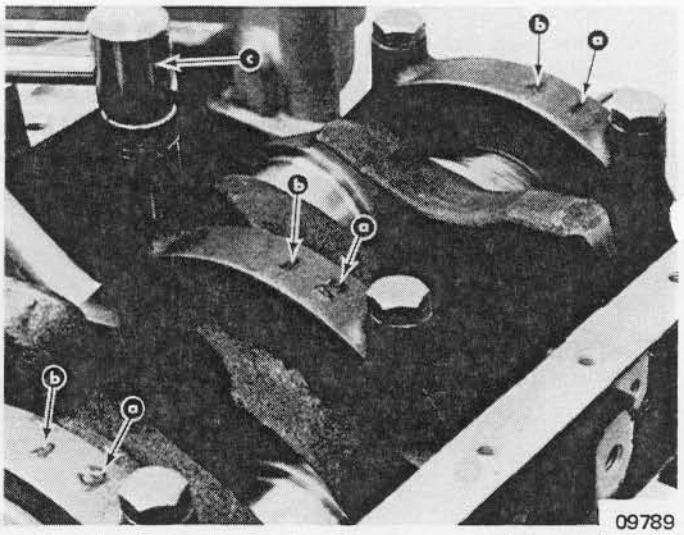
Figure 6. Applying Sealer to Cylinder Block

5. Apply Perfect Seal to outside face of side seals on rear cap to facilitate installation. Install rear cap, being careful that side seal does not move up cap groove. With rear cap installed, seal end still must protrude from block side of cap.
6. Install cap fastening bolts and torque to specifications.
7. Use .015" feeler gauge as guide (Figure 7) and cut side seals (one each side) to extend .015" from bottom (oil pan side) of bearing cap.
8. Install 4 other bearing caps with cast arrow pointing toward front of engine (Figure 8) and cast numbers i



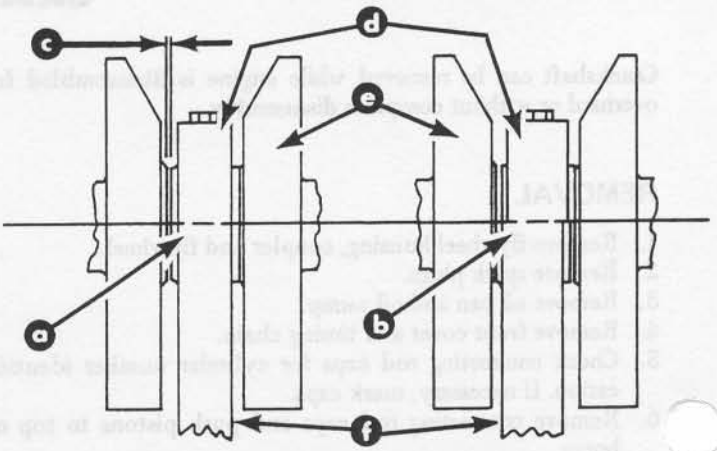
a - Feeler Gauge b - Seal (One Each Side) c - Knife

Figure 7. Cutting Rear Main Side Seals



a - Cast Numbers b - Cast Arrows c - Torque Wrench

Figure 8. Installing Bearing Caps



a - Correct Alignment d - Bearing Cap
b - Alignment Not Correct e - Crankshaft
c - Crankshaft End Play f - Cylinder Block

Figure 9. No. 3 Bearing Cap Installation

their respective location. Torque all bearing cap bolts (except No. 3) to specifications.

9. To prevent misalignment of thrust bearing (located at No. 3 bearing cap), pry crankshaft toward front of engine, then toward rear of engine. With crank in this position, torque bolts to specifications. Correct bearing alignment is shown in Figure 9.
10. Check crankshaft end play with feeler gauge between thrust bearing and crankshaft.
11. Check that crankshaft turns freely with little effort. If crank does not turn freely, bearing clearances, bearing and journal diameters and crank straightness should be checked.
12. Reinstall connecting rods. Refer to "Connecting Rod and Piston Installation", following.
13. Install front cover, oil pump, oil pan, spark plugs, flywheel, coupler and flywheel housing. Refer to "Index" for particular installation procedures.

MAIN BEARINGS

Main bearings are precision insert type and do not utilize shims for adjustment. If clearances are found to be excessive, a new bearing (both upper and lower halves) is required. Bearings are available in standard size and .002" and .020" (0.051mm to 0.51mm) undersize.

When a production standard crankshaft journal cannot be precision-fit, it then is ground .002" undersize on all main journals (.002" will be stamped on crankshaft front counterweight, as shown in Figure 4, following).

REMOVAL

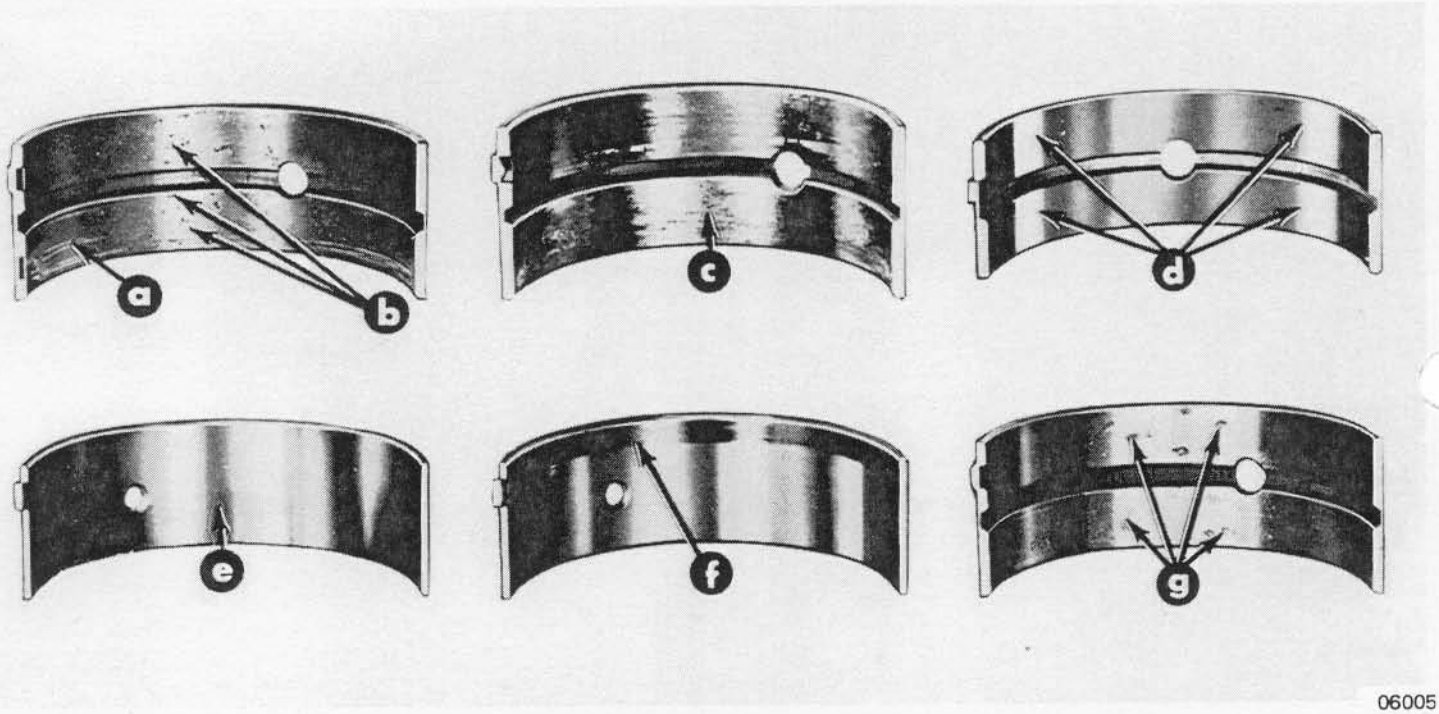
Refer to "Crankshaft Removal", preceding. Place used bearings so that they can be installed in same location from where they were removed.

CLEANING and INSPECTION

Clean bearing inserts and caps thoroughly in solvent and dry with compressed air. DO NOT scrape gum or varnish deposits from bearing shells.

Inspect each bearing carefully. Replace bearings with scored, chipped or worn surface.

In general, lower half of bearing shows greater wear and most distress from fatigue. If lower half shows evidence of wear or damage, replace both upper and lower halves. Never replace one half without replacing other half. Typical bearing failures are shown in Figure 1, following.



a - Scratched by Dirt
b - Dirt Embedded into Bearing Material
c - Overlay Wiped Out (Lack of Oil)
d - Bright Polished Sections (Improper Seating)
e - Overlay Gone from Entire Surface (Tapered Journal)
f - Radius Ride
g - Craters or Pockets (Fatigue Failure)

Figure 1. Typical Bearing Failure

CHECKING CLEARANCE

To obtain accurate results, use Plastigage (or its equivalent), a wax-like plastic material that will compress evenly between bearing and journal surfaces without damaging either surface.

With engine upside-down, crankshaft will rest on upper bearings, and total clearance can be measured between lower bearing and journal.

NOTE: To assure proper seating of crankshaft, torque all bearing cap bolts as specified. In addition, before checking fit of bearings, wipe surface of crankshaft journal and face and back of bearing clean of oil.

1. With oil pan and oil pump removed, and starting with rear main bearing, remove bearing cap and wipe oil from journal and bearing cap.
2. Place piece of gauging plastic the full width of bearing (parallel to crankshaft) on journal. (Figure 2)

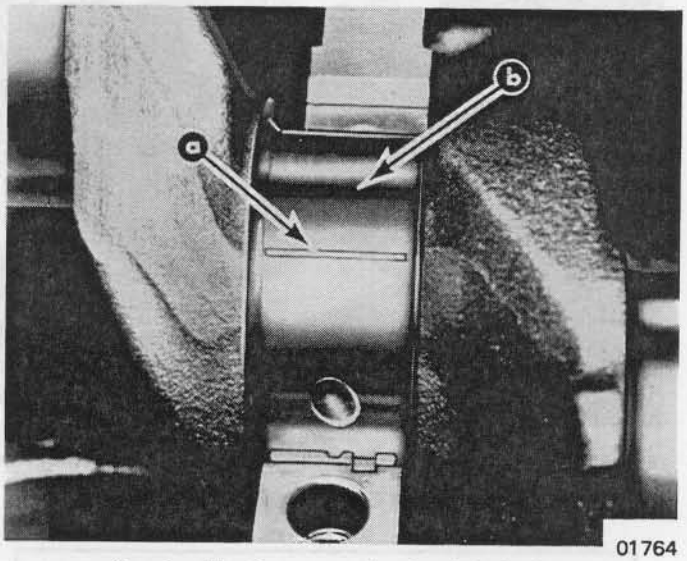
CAUTION: DO NOT rotate crankshaft while the gauging plastic is between bearing and journal.

3. Install bearing cap and torque retaining bolts evenly to specifications.
4. Remove bearing cap. Flattened gauging plastic will be found adhering to either bearing shell or journal.
5. Edge of gauging plastic envelope has a graduated scale (in thousandths of an inch). Without removing gauging plastic, measure its compressed width (at widest point) with graduations on gauging plastic envelope. (Figure 3)

NOTE: Normally, main bearing journals wear evenly and are not out-of-round. However, if a bearing is being fitted

to an out-of-round journal [.001" (.025mm) max.], be sure to fit to maximum diameter of journal. If bearing is fitted to minimum diameter, and journal is out-of-round .001", interference between bearing and journal will result in rapid bearing failure. If flattened gauging plastic tapers toward middle or ends, there is a difference in clearance that indicates taper, low spot or other irregularity of bearing or journal. Be sure to measure journal with a micrometer, if flattened gauging plastic indicates more than .001" difference.

6. If bearing clearance is within specifications, bearing insert is satisfactory. If clearance is not within specifications, replace insert. Always replace both upper and lower insert as a unit.
7. A standard or .002" (0.051mm) undersize bearing may produce proper clearance. If not, regrind crankshaft journal for use with next undersize bearing. Reinstall bearing cap.



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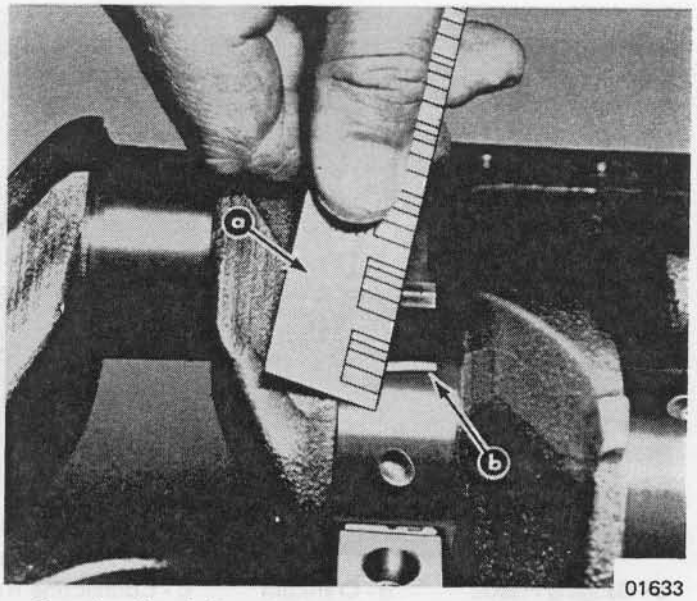
a - Gauging Plastic b - Crankshaft Journal

Figure 2. Gauging Plastic on Journal



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a - Gauging Plastic Envelope b - Gauging Plastic Compressed

Figure 3. Measuring Gauging Plastic

8. Proceed to next bearing. After all bearings have been checked, rotate crankshaft so that no excessive drag exists.
9. After bearing fit is correct, remove crankshaft and oil bearing surfaces and reinstall crankshaft. Refer to "Crankshaft Installation", preceding.

MAIN BEARING REPLACEMENT

1. Remove and inspect crankshaft.
2. Remove main bearings from cylinder block and main bearing caps.
3. Coat bearing surfaces of new, correct-size main bearings with oil and install in cylinder block and main bearing caps. Check clearance outlined.
4. Install crankshaft. (See "Crankshaft Installation", preceding.)

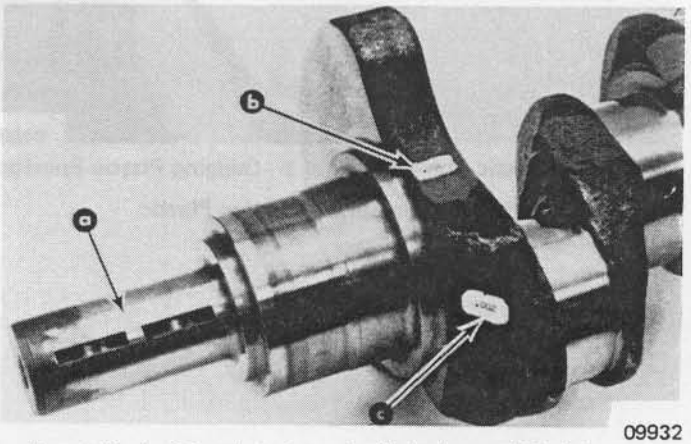
CONNECTING ROD BEARINGS

Connecting rod bearings are precision insert type and do not utilize shims for adjustment. DO NOT FILE RODS OR ROD CAPS. If clearances are found to be excessive, a new bearing is required. Bearings are available in standard size and .002" (0.051mm) undersize for new and used standard size crankshaft and in .020" (0.51mm) undersize for reconditioned crankshafts.

When a production standard crankshaft journal cannot be precision-fit, it then is ground .002" undersize on all rod journals (.002" will be stamped on crankshaft front counterweight, as shown in Figure 4).

INSPECTION and REPLACEMENT

1. With oil pan and oil pump removed, lift off connecting rod cap and bearing.
2. Inspect bearing for evidence of wear or damage (defective bearings should not be installed). Typical bearing failures are shown in Figure 1, preceding.
3. Wipe bearings and crankpin clean of oil.
4. Measure crankpin for out-of-round or taper with a micrometer. If not within specifications, replace or recondition



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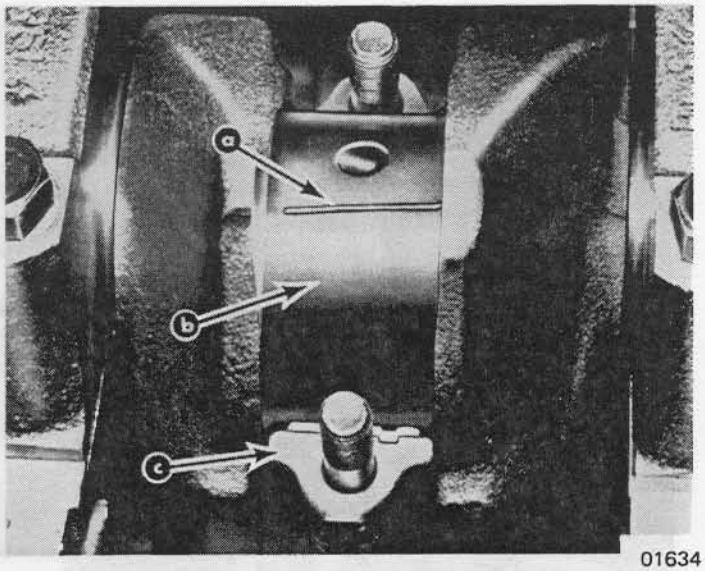
a - Front End of Crankshaft b - Main Journal Mark Location
c - Rod Journal Mark Location

Figure 4. Undersize Journal Identification



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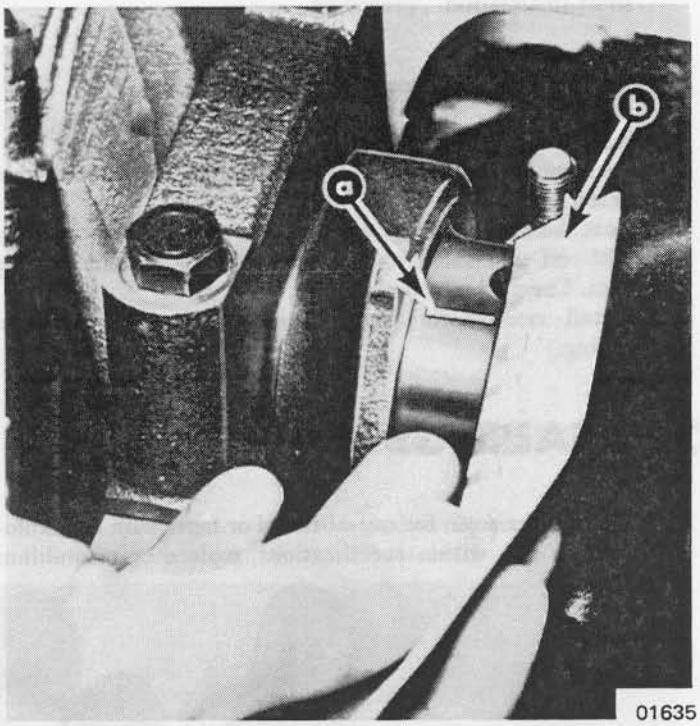
a - Gauging Plastic b - Crankpin c - Connecting Rod

Figure 5. Gauging Plastic on Crankpin

crankshaft. If within specifications and new bearing is to be installed, measure maximum diameter of crankpin to determine new bearing size required.

5. If within specifications, measure new or used bearing clearances with Plastigage or equivalent, as follows:



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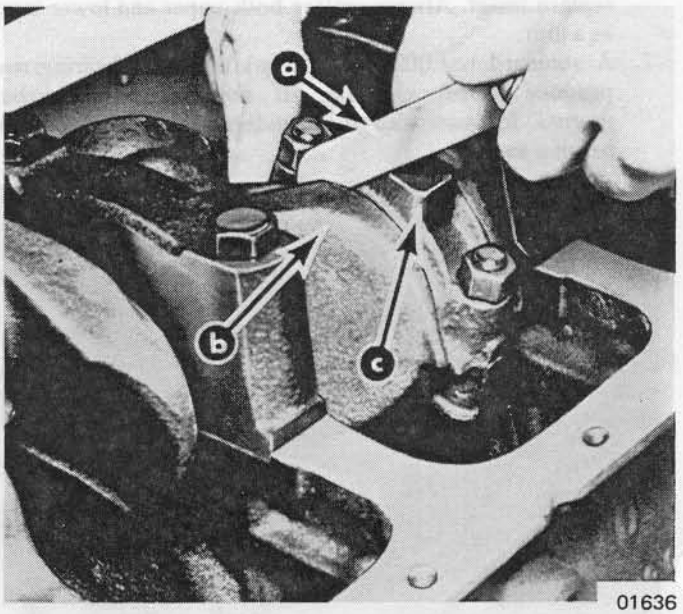
a - Gauging Plastic Compressed b - Gauging Plastic Envelope

Figure 6. Measuring Gauging Plastic

NOTE: If bearing is being fitted to out-of-round crankpin, be sure to fit maximum diameter of crankpin. If bearing is fitted to minimum diameter, and crankpin is out-of-round .001" (0.025mm), interference between bearing and crankpin will result in rapid bearing failure.

a. Place a piece of gauging plastic the full width of crankpin (parallel to crankshaft). (Figure 5)
b. Install bearing, connecting rod and cap. Take care that tab in bearings is located correctly in rod and rod cap notches.
c. Install bearing cap and torque nuts evenly to specifications.



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a - Feeler Gauge b - Crankshaft c - Connecting Rod

Figure 7. Measuring Connecting Rod Side Clearance

CAUTION: DO NOT turn crankshaft with gauging plastic installed.

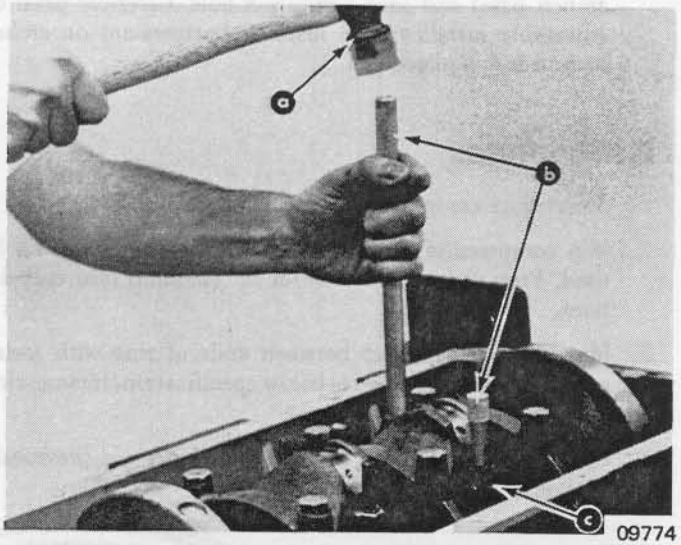
d. Remove bearing cap and, using scale on gauging plastic envelope, measure gauging plastic width at widest point. (Figure 6)

6. If clearance exceeds specifications, select a new, correct-size bearing and remeasure clearance.
7. Coat bearing surface with oil, install rod cap and torque nuts to specifications.
8. When all connecting rod bearings have been installed, tap each rod lightly (parallel to crankpin) to be sure that they have clearance.
9. Measure all connecting rod side clearances (see specifications) between connecting rod and side of crankpin. (Figure 7)

PISTON and ROD ASSEMBLY

REMOVAL

1. Remove flywheel housing, coupler and flywheel.
2. Remove cylinder head assembly (see "Index").
3. Remove oil pan and oil pump.
4. Check connecting rod caps for cylinder number identification. If necessary, mark rod caps and rods.
5. Remove connecting rod caps. Install Rod Guides (J-5239) on connecting rod bolts and push or tap pistons out top of cylinder bores. (Figure 1)

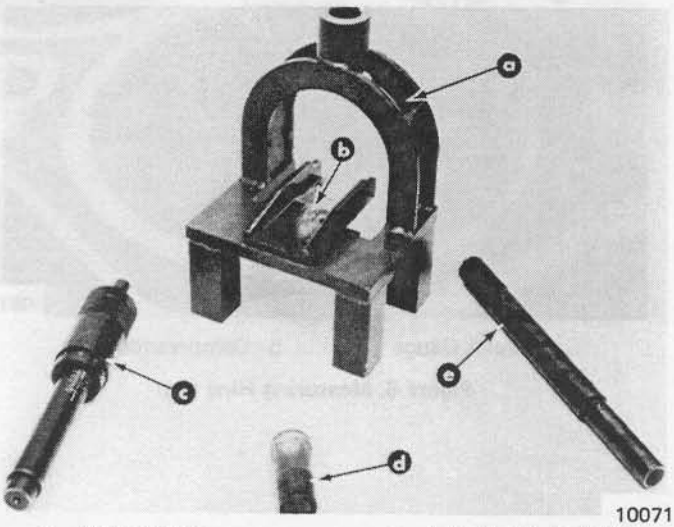


a - Mallet b - Rod Guide Tool c - Connecting Rod

Figure 1. Removing Piston and Rod Assembly

DISASSEMBLY

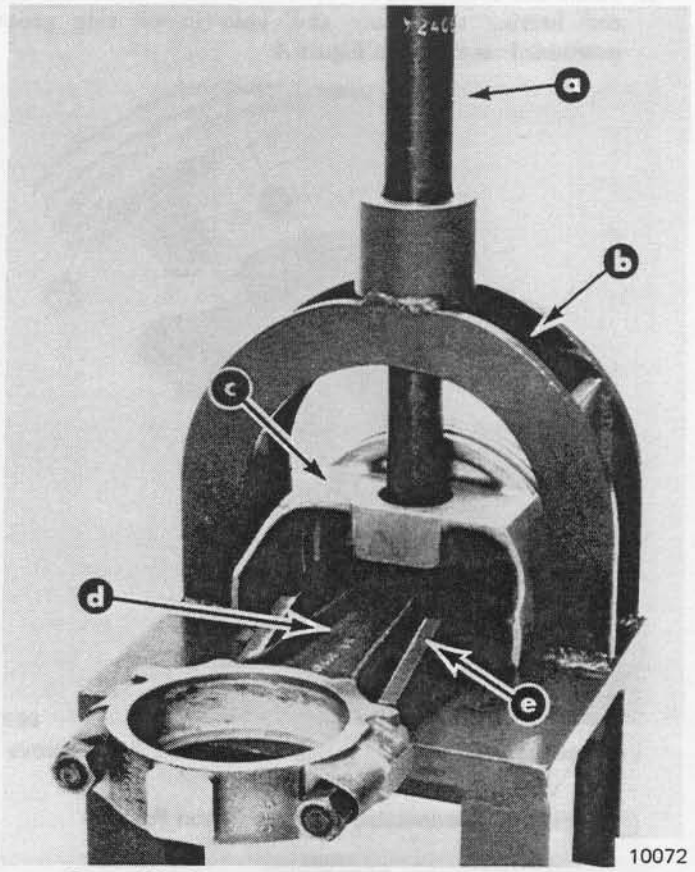
1. Use Tool Kit (J-24086-100), shown in Figure 2.



a - Arched Base c - Adjustable Installer
b - Rod Support d - Piston Pin Guide
e - Piston Pin Remover

Figure 2. Tool (J-24086-100) Parts Identification

2. Position connecting rod onto tool rod support with rod support inserted between connecting rod end and piston. Align piston pin with hole located in top of arched base. (Figure 3)
3. Insert pin remover thru hole (located in top of arched base) and into piston pin hole. Press on pin remover to remove piston pin. (Figure 3)



a - Piston Pin Remover c - Piston
b - Arched Base d - Connecting Rod
e - Rod Support

Figure 3. Removing Piston Pin

CLEANING and INSPECTION

Connecting Rods

1. Wash connecting rods in cleaning solvent and dry with compressed air.
2. Check for twisted or bent rods and inspect for cracks. Replace damaged rods.

Pistons

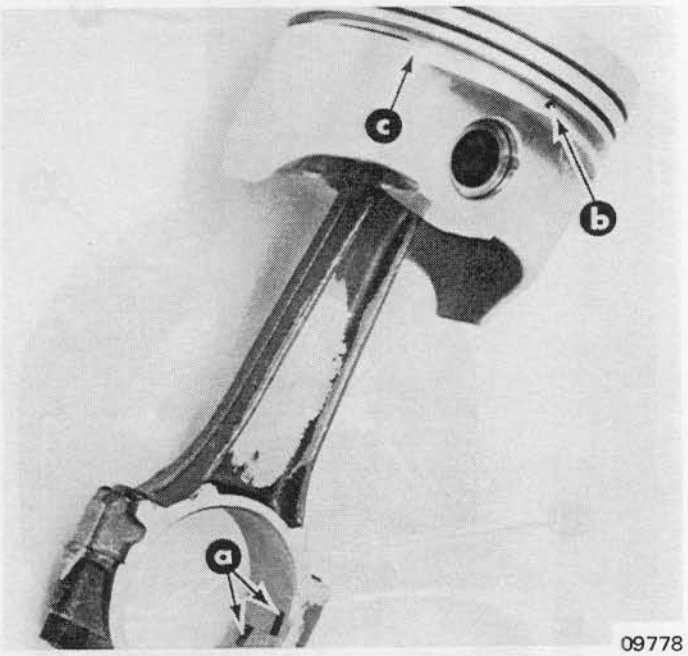
1. Clean varnish from piston skirts and pins with cleaning solvent. DO NOT WIRE BRUSH ANY PART OF PISTON.
2. Clean ring grooves with groove cleaner (or broken ring).
3. Inspect piston for cracked ring lands, skirts or pin bosses, wavy or worn ring lands, scuffed or damaged skirts and eroded areas at top of piston. Replace pistons which are damaged or have excessive wear.
4. Inspect piston ring grooves for nicks or burrs which might cause rings to hang up.
5. Measure piston skirt (across centerline of piston pin) and check clearance as outlined under "Piston Selection". (See "Index".)

Piston Pins

1. Piston and piston pin are matched and not serviced separately.
2. Pin bores and piston pins must be free of varnish or scuffing. Measure piston pin with micrometer and piston pin bore with bore gauge or inside micrometer. If clearance is in excess of wear limit (see specifications), replace piston and pin assembly.

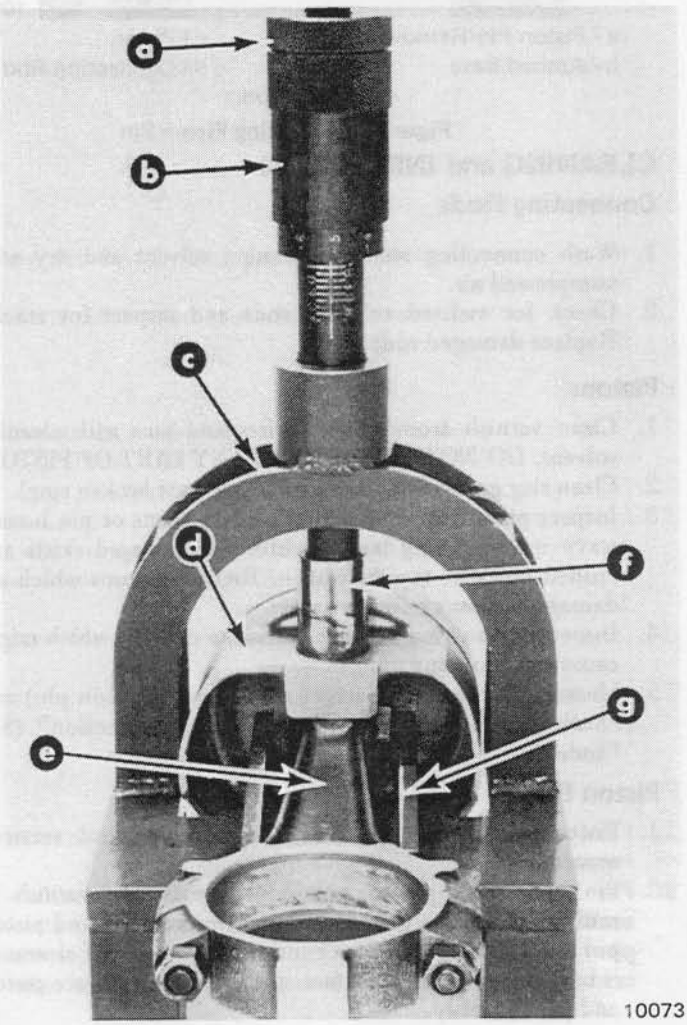
REASSEMBLY

1. Piston and connecting rod are reassembled with connecting rod bearing tang slots and hole in oil ring groove positioned as shown in Figure 4.



a - Bearing Tang Slots b - Hole in Oil Ring Groove
c - Oil Ring Groove

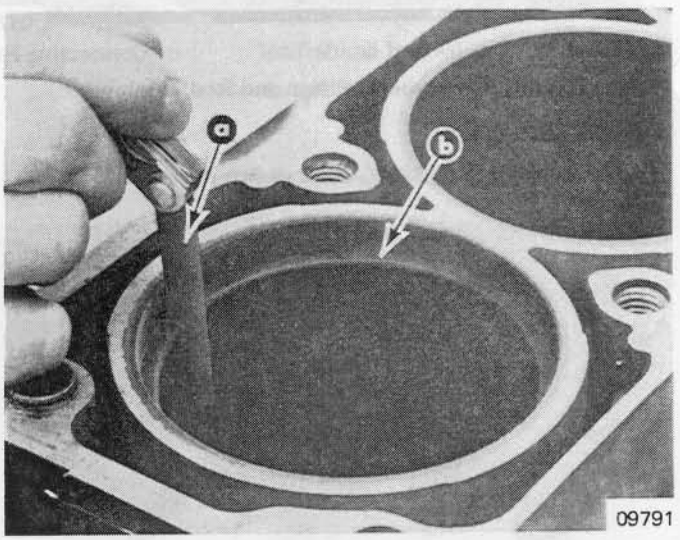
Figure 4. Connecting Rod and Piston Position



2. Lubricate piston pin, piston pin hole in piston and hole in rod end with a light coat of engine oil.
3. Position rod onto rod support and piston onto rod end, as shown in Figure 4. Insert piston pin guide thru bottom piston pin hole and into connecting rod. Place piston pin thru top side of piston. (Figure 5)
4. Adjust adjustable installer to setting specified on chart (which came with tool) for particular piston installation. Lock adjustable installer with jam nut.
5. Insert adjustable installer thru hole (located on top of arched base) and into piston pin hole. Carefully press on adjustable installer until installer bottoms-out on arched base to install piston pin.

PISTON RINGS

1. Select rings comparable in size to piston being used.
2. Slip compression ring in cylinder bore where ring will be used. Press ring squarely about ¼" (6.4mm) into cylinder bore.
3. Measure space or gap between ends of ring with feeler gauge. (Figure 6) If gap is below specification, remove ring and try another for fit.
4. Clean, inspect and fit piston to cylinder (as previously outlined), if not already completed.



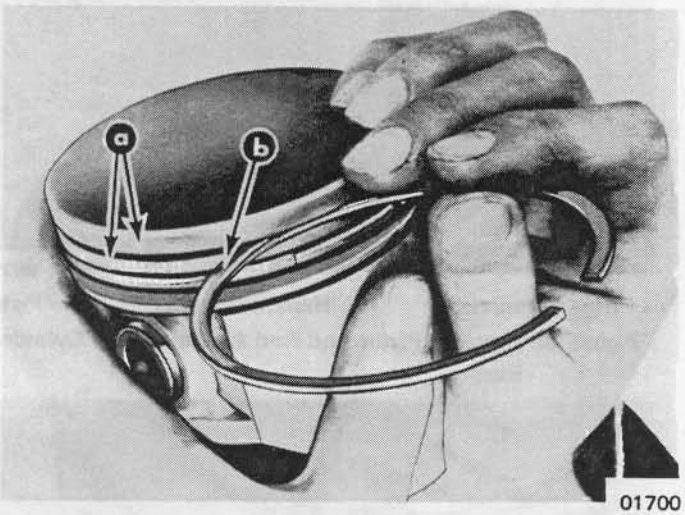
a - Feeler Gauge b - Compression Ring

Figure 6. Measuring Ring Gap

a - Jam Nut
b - Adjustable Installer
c - Arched Base
d - Piston
e - Connecting Rod
f - Piston Pin
g - Rod Support

Figure 5. Installing Piston Pin

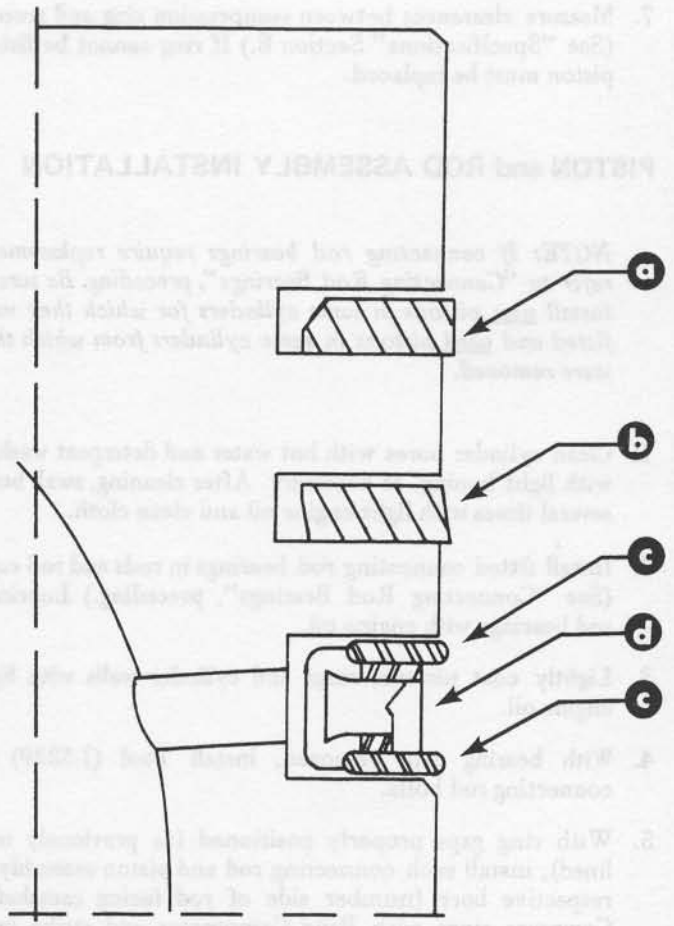
5. Insert outer surface of top and second compression ring into respective piston ring groove and roll ring entirely around groove (Figure 7) to make sure that ring fit is free. If binding occurs at any point, determine the cause and, if caused by ring groove, remove by dressing with fine cut file. If binding is caused by distorted ring, use new ring.



a - Piston Ring Groove (Top and Second) b - Piston Ring

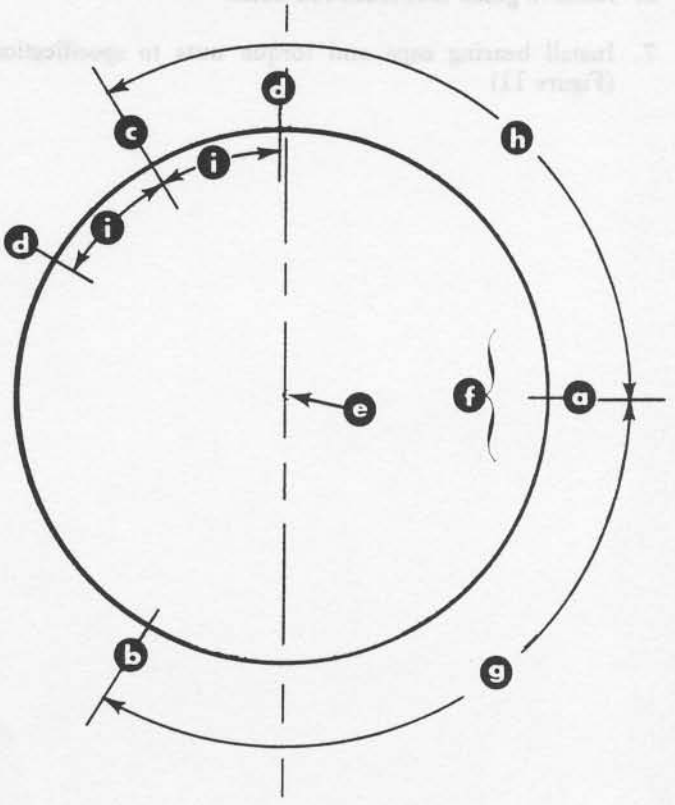
Figure 7. Checking Ring in Groove

6. Refer to Figures 8 and 9 for piston ring installation and complete the following:
   a. Install oil expander ring in groove with gap located 120° clockwise from No. 1 compression ring gap (starboard side of piston), as shown in Figure 9.
   b. Hold expander ends butted and install lower steel oil ring rail with gap located approximately 1" (25.4mm) to one side of expander gap. (Figures 8 and 9)
   c. Install upper steel oil ring rail with gap located approximately 1" to other side of expander gap. (Figures 8 and 9)
   d. Install second compression ring in piston second groove (Figure 8) with gap located 120° counterclockwise from No. 1 compression ring gap (starboard side of piston), as shown in Figure 9.
   e. Install top compression ring with gap located at starboard side of piston (starboard or camshaft side of piston has a hole located in oil ring groove). (See Figure 3 in "Piston and Rod Assembly - Reassembly", preceding.)



a - Top Compression Ring
b - Second Compression Ring
c - Top and Lower Steel Oil Ring Rail
d - Oil Expander Ring

Figure 8. Piston Ring Identification



a - Top Compression Ring Gap Location
b - Second Compression Ring Gap Location
c - Oil Expander Ring Gap Location
d - Top and Lower Steel Oil Ring Rail Gap Location
e - Centerline
f - Starboard or Camshaft Side of Piston with Hole Located in Oil Ring Groove
g - 120° Clockwise from No. 1 Compression Ring Gap Location
h - 120° Counterclockwise from No. 1 Compression Ring Gap Location
i - Approximately 1"

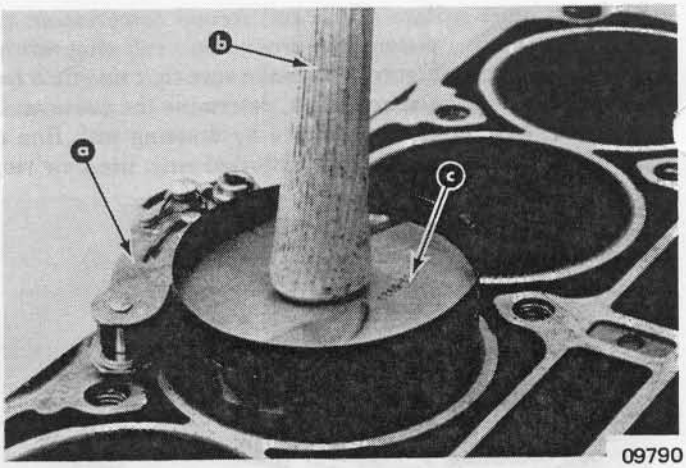
Figure 9. Piston Rings Gap Location

7. Measure clearances between compression ring and groove. (See "Specifications" Section 8.) If ring cannot be fitted, piston must be replaced.

PISTON and ROD ASSEMBLY INSTALLATION

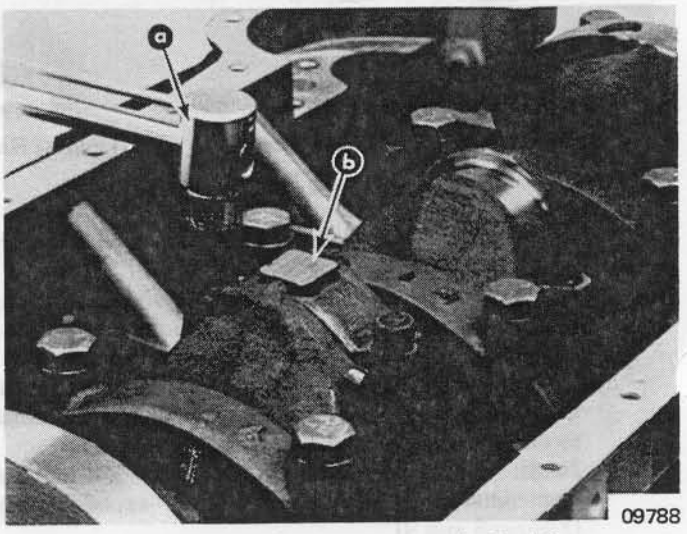
NOTE: If connecting rod bearings require replacement, refer to "Connecting Rod Bearings", preceding. Be sure to install new pistons in same cylinders for which they were fitted and used pistons in same cylinders from which they were removed.

1. Clean cylinder bores with hot water and detergent wash or with light honing, as necessary. After cleaning, swab bores several times with light engine oil and clean cloth.
2. Install fitted connecting rod bearings in rods and rod caps. (See "Connecting Rod Bearings", preceding.) Lubricate rod bearings with engine oil.
3. Lightly coat pistons, rings and cylinder walls with light engine oil.
4. With bearing caps removed, install Tool (J-5239) on connecting rod bolts.
5. With ring gaps properly positioned (as previously outlined), install each connecting rod and piston assembly in respective bore (number side of rod facing camshaft). Compress rings with Ring Compressor and strike light blows with hammer handle to install piston into bore. (Figure 10) Hold ring compressor firmly against block until all piston rings have entered cylinder bore.
6. Remove guide tool from rod bolts.
7. Install bearing caps and torque nuts to specifications. (Figure 11)



a - Ring Compressor b - Hammer Handle c - Piston

Figure 10. Installing Piston and Rod Assembly into Cylinder Bore



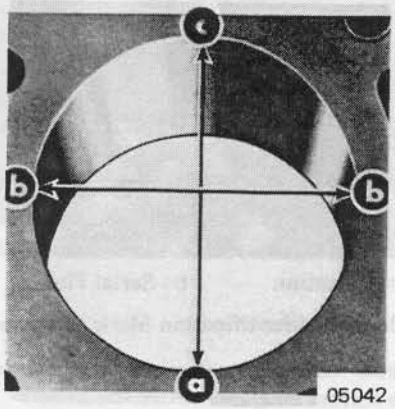
a - Torque Wrench b - Rod Cap

Figure 11. Torquing Rod Cap

CLEANING and INSPECTION

1. Wash cylinder block thoroughly in cleaning solvent and clean all gasket surfaces.
2. Remove oil gallery plugs and clean all oil passages.

   NOTE: Remove plugs with a sharp punch or drill and pry out.

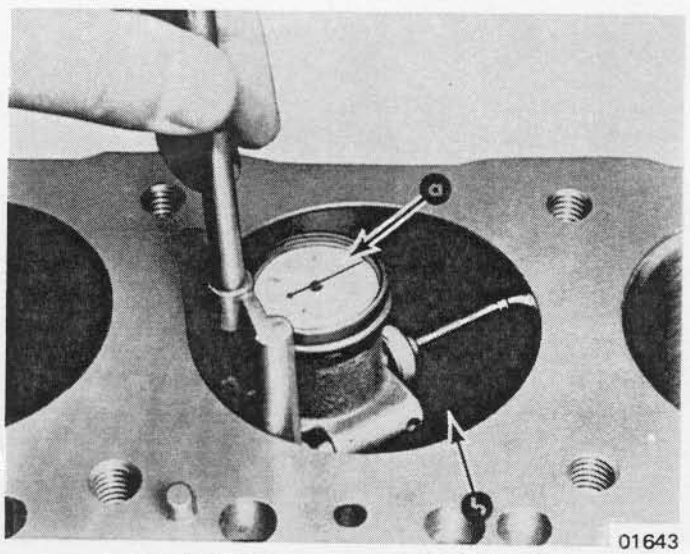


a - At Right Angle to Centerline of Engine
b - Parallel to Centerline of Engine

Taper - Difference between "a" Measurement at Top of Cylinder Bore and "a" Measurement at Bottom of Cylinder Bore
Out-of-Round - Difference between "a" and "b"
c - Centerline of Engine

Figure 1. Cylinder Measurement

3. Clean and inspect water passages in cylinder block.
4. Inspect cylinder block for cracks in cylinder walls, water jacket valve lifter bores and main bearing webs.
5. Measure the cylinder walls for taper, out-of-round or excessive ridge at top of ring travel (Figure 1) with dial indicator. (Figure 2) Set gauge so that thrust pin must be forced in about ¼" (6.4mm) to enter gauge in cylinder bore. Center gauge in cylinder and turn dial to "O". Carefully work gauge up-and-down cylinder to determine taper and turn gauge to different points around cylinder wall to determine out-of-round condition. If cylinders exceed specifications, honing and/or boring are necessary.



a - Dial Indicator b - Cylinder Bore

Figure 2. Measuring Typical Cylinder Bore

REPAIRS

Cylinder Conditioning

Condition of engine at time of repair is important. If inspection indicates that cylinder block is acceptable, except for out-of-round or tapered cylinders, condition the block by honing or boring.

If cylinders have less than .005" (0.127mm) taper or wear, condition them with a hone and fit with high-limit, standard size piston. A cylinder bore of less then .005" wear or taper may not clean up entirely when fitted to a high limit piston. If such is the case, clean up bore entirely by reboring for an oversize piston. If more than .005" taper or wear, bore and hone to smallest oversize that permits complete resurfacing of all cylinders.

When pistons are fitted (honing not necessary), clean (scrub) cylinder bores with detergent and hot water. After cleaning, swab cylinder bores several times with light engine oil on clean cloth, then wipe with clean, dry cloth.

Cylinder Boring

1. Before using any type boring bar, file off top of cylinder block to remove dirt or burrs. This will guard against a tilted boring bar and assures that rebored cylinder wall is at right angles to crankshaft.
2. Measure piston to be fitted with a micrometer at center of piston skirt and at right angles to piston pin. Bore cylinder to same diameter as piston and hone cylinder to specifications (Section 8) and as outlined under "Cylinder Honing" and "Piston Selection", following.
3. Carefully follow instructions furnished by manufacturer of equipment being used.

Cylinder Honing

1. Follow hone manufacturer's recommendations for use of hone and cleaning and lubrication during honing.
2. Occasionally, during honing operation, thoroughly clean cylinder bore and check piston for correct fit in cylinder.
3. When finish-honing a cylinder bore to fit a piston, move hone up-and-down to obtain very fine uniform surface finish marks in a cross-hatch pattern of approximately 30° to cylinder bore. Finish marks should be clean but not sharp and free from imbedded particles and torn or folded metal.

CAUTION: Handle pistons with care and DO NOT attempt to force them thru cylinder until cylinder has been honed to correct size, as this type piston can be distorted thru careless handling.

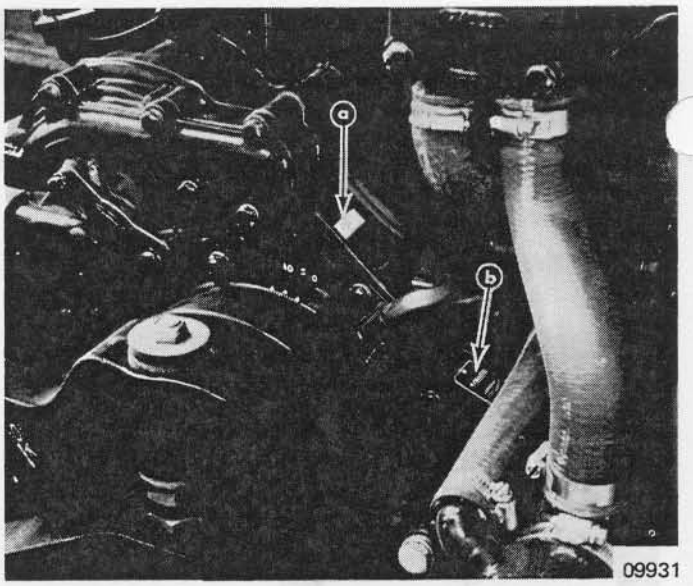
4. Permanently mark piston for cylinder to which it has been fitted and proceed to hone cylinders and fit remaining pistons.
5. Thoroughly clean cylinder bores with hot water and detergent. Scrub well with a stiff bristle brush and rinse thoroughly with hot water. Be absolutely certain that no abrasive material is allowed to remain in cylinder bores, or it will rapidly wear new rings and cylinder bores in

addition to bearings lubricated by contaminated oil. Swab bores several times with light engine oil on a clean cloth, then wipe with a clean, dry cloth. DO NOT clean cylinder with kerosene or gasoline. Clean remainder of cylinder block to remove excess material spread during honing operation.

PISTON SELECTION

When a production standard piston cannot be precision-fit, cylinder bore is enlarged .005" (0.127mm) and oversize pistons are installed in all cylinders (.005" is stamped on cylinder block in area shown in Figure 3).

1. Check USED piston to cylinder bore clearance as follows:
   a. Measure "Cylinder Bore Diameter" with a telescope gauge 2½" (63.5mm) from top of cylinder bore.
   b. Measure "Piston Diameter" (at skirt across centerline of piston pin).
   c. Subtract piston diameter from cylinder bore diameter to determine "Piston to Bore Clearance".
   d. Determine if piston to bore clearance is in acceptable range. (See "Specifications" in Section 8.)
2. If used piston is not acceptable, check oversize pistons available. Refer to Parts Manual.
3. If cylinder bore must be reconditioned, measure new piston diameter (across centerline of piston pin), then hone cylinder bore to correct clearance.
4. Mark piston to identify cylinder for which it was fitted.

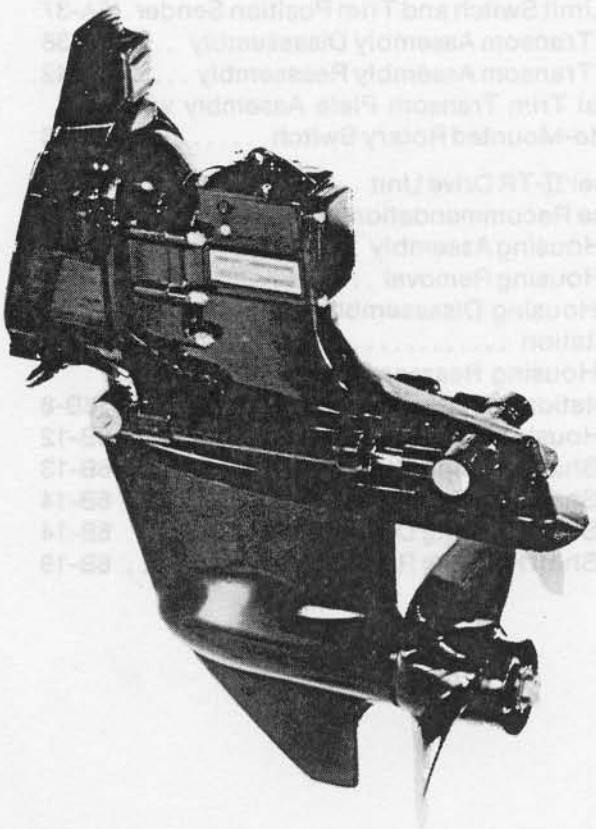


a - Identification Mark Location b - Serial Plate

Figure 3. Oversize Cylinder Bore Identification Mark Location

DRIVE SYSTEMS

MERCRUISER Section 6



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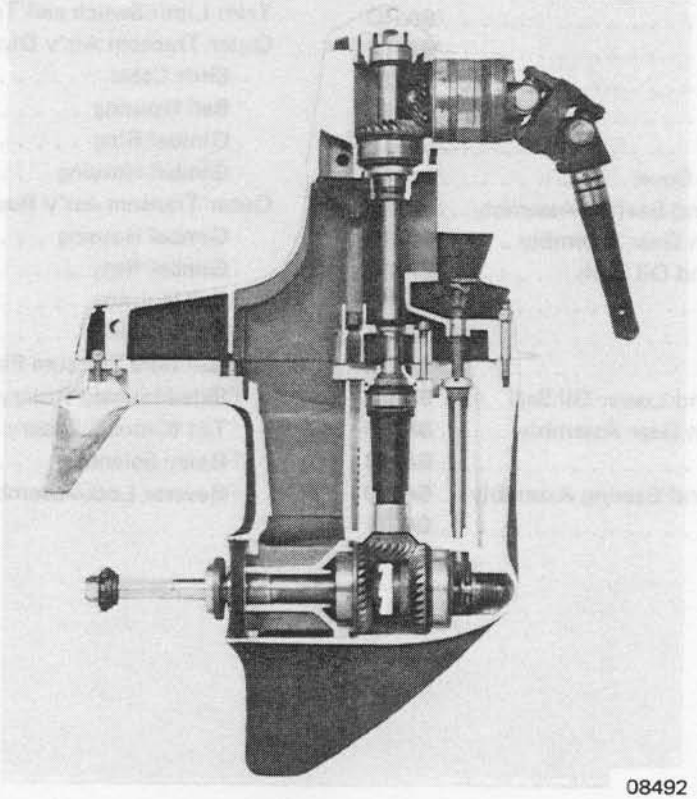
SECTION 6 - DRIVE SYSTEMS

mercruiser

PART A - MERCRUISER I-DRIVE UNIT



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MERCURY MARINE

A BRUNSWICK COMPANY

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GENERAL SERVICE RECOMMENDATIONS

Instructions are printed in the sequence which will be followed to assure best results when removing or replacing components. Follow "Disassembly" and "Reassembly" procedures as written, however, if complete disassembly is not necessary, start reassembly at point that disassembly was stopped (use "Index"). In order to assure correct and durable operation after assembly, it is important that all adjustments and torque value specifications be maintained to the highest degree of accuracy.

Use special service tools, where specified, and use common tools of proper fit when removing and replacing parts.

When holding housings or parts in a vise -- or by other means -- use blocks of wood and/or brass shields to prevent marring parts' surfaces. Pressed-on parts (bearings, gears, etc) require adapting appropriate mandrels and supports for the press used. Do not apply force on the bearing cages, mating surfaces or edges which will mar or fail if force is applied. When pressing bearings or bearing cups into housings or onto shafts and gears, apply thin coat of Multipurpose Lubricant (C-92-63250) to contact surfaces.

To prevent corrosive action during reassembly, apply Perfect Seal (C-92-34227) to external parts of bearing carrier, bearing carrier retainer and housing mating surfaces. DO NOT allow sealer to contact "O" rings or enter bearings and gears. To ease installation of drive unit components, apply Multipurpose Lubricant to lip of all oil seals and "O" rings.

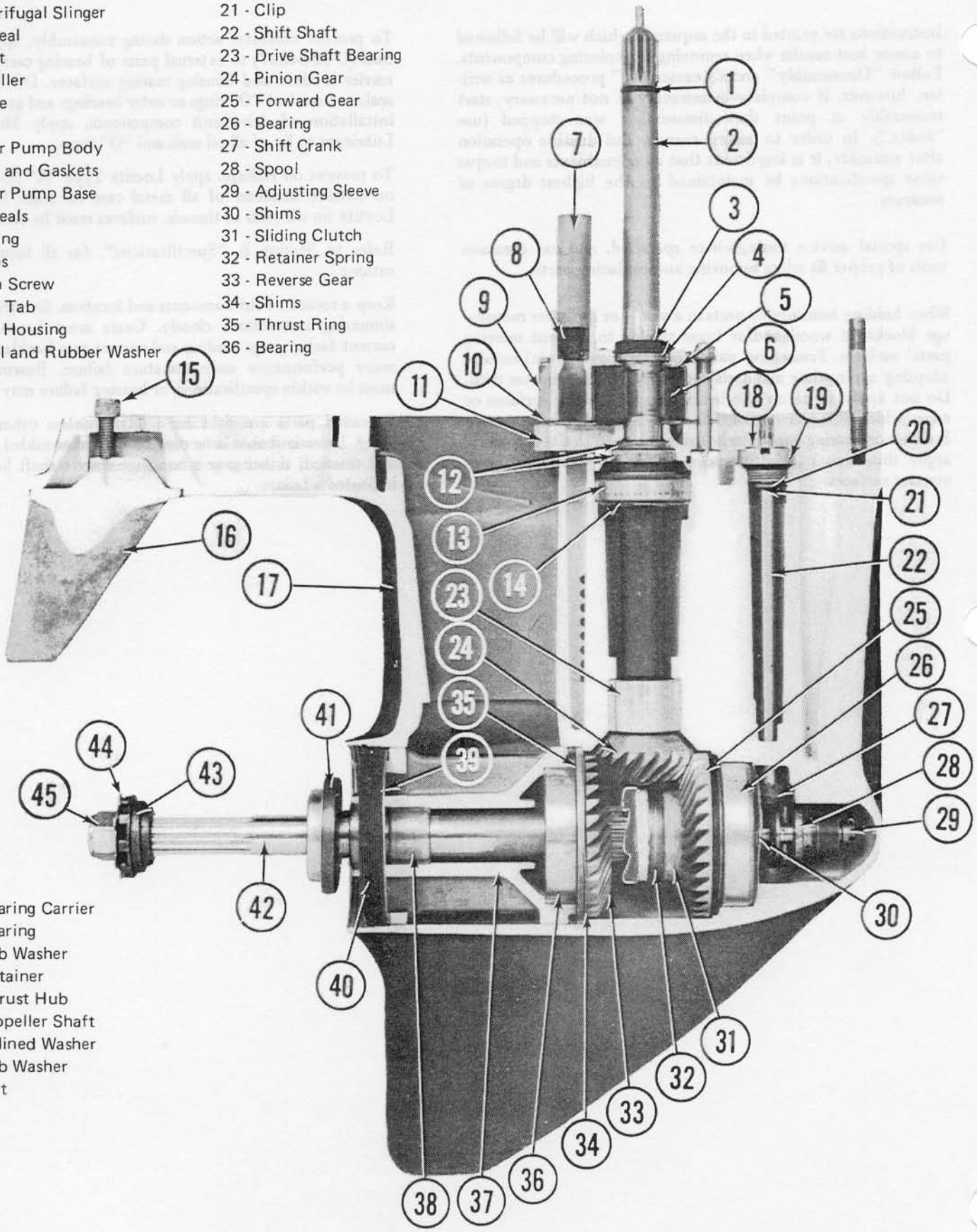
To prevent oil leakage, apply Loctite Type "A" (C-92-32609) on outside diameter of all metal case oil seals. When using Loctite on oil seals or threads, surfaces must be clean and dry.

Refer to Section 8, "Specifications", for all torque specifications.

Keep a record of shim amounts and location. Be sure to follow shimming instructions closely. Gears must be mounted to correct feeler gauge reading and correct gear backlash to avoid noisy performance and premature failure. Bearing preload must be within specifications, or bearing failure may result.

Threaded parts are right hand (RH), unless otherwise indicated. Drive unit should be completely disassembled, inspected and cleaned, if either gear housing or drive shaft housing has indicated a failure.

1 - "O" Ring
2 - Drive Shaft
3 - Centrifugal Slinger
4 - Oil Seal
5 - Insert
6 - Impeller
7 - Guide
8 - Seal
9 - Water Pump Body
10 - Plate and Gaskets
11 - Water Pump Base
12 - Oil Seals
13 - Bearing
14 - Shims
15 - Allen Screw
16 - Trim Tab
17 - Gear Housing
18 - Metal and Rubber Washer
19 - Shift Shaft Bushing
20 - Washer
21 - Clip
22 - Shift Shaft
23 - Drive Shaft Bearing
24 - Pinion Gear
25 - Forward Gear
26 - Bearing
27 - Shift Crank
28 - Spool
29 - Adjusting Sleeve
30 - Shims
31 - Sliding Clutch
32 - Retainer Spring
33 - Reverse Gear
34 - Shims
35 - Thrust Ring
36 - Bearing



37 - Bearing Carrier
38 - Bearing
39 - Tab Washer
40 - Retainer
41 - Thrust Hub
42 - Propeller Shaft
43 - Splined Washer
44 - Tab Washer
45 - Nut

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Figure A. Gear Housing Parts Identification

GEAR HOUSING REMOVAL

1. Drain lubricant from drive unit by removing drain plug from lower end of gear housing on left side (Figure 1) and vent plug on drive shaft housing. (Figure 2)

   NOTE: Vent plug may be located on either side of drive shaft housing.

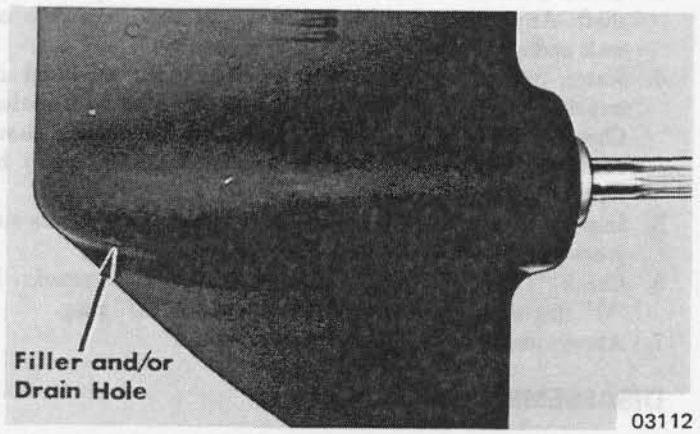

Figure 1. Drain Plug in Gear Housing

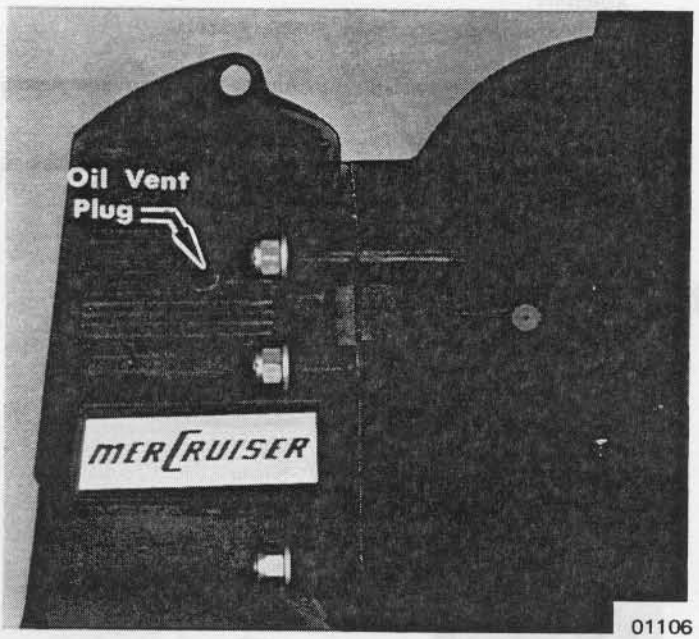

Figure 2. Vent Plug in Drive Shaft Housing

CAUTION: If metal particles or water are present in drive unit lubricant, both gear housing and drive shaft housing must be disassembled, cleaned in solvent and closely inspected. Replace all oil seals and any unserviceable parts.

2. Place a block of wood between propeller and anti-cavitation plate to prevent propeller from turning while removing propeller nut.
3. Remove propeller by bending tabs on tab washer and removing propeller nut (right hand thread), tab washer, splined washer, propeller and thrust hub assembly. (Figure 3)

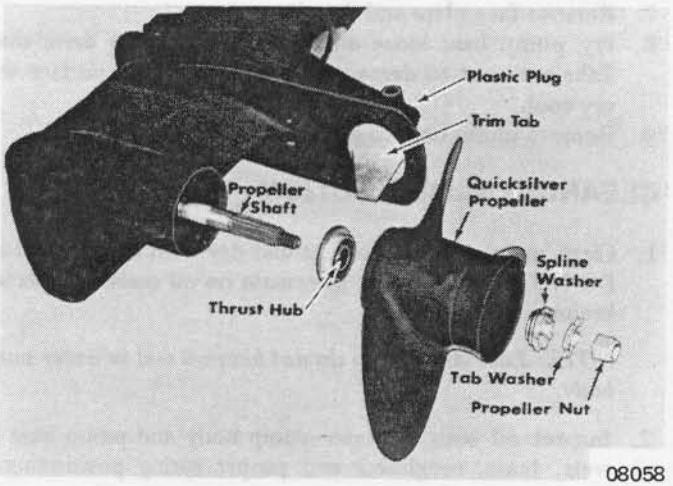

Figure 3. Propeller and Gear Housing Removal

4. Remove trim tab under trailing edge of anti-cavitation plate by removing plastic plug from rear top of drive shaft housing and turning allen head screw out of trim tab. (Figure 3)
5. Remove gear housing allen head screw from inside trim tab cavity.
6. Remove five 5/8" hexagon head locknuts which hold gear housing assembly to drive shaft housing. (Figure 3)
7. Separate gear housing from drive shaft housing.

   NOTE: If gear housing is to be disassembled, check backlash between gears at this time (for future reference). Refer to "Shimming (Forward and Reverse Gears)" under "Gear Housing Reassembly" (see "Index").

GEAR HOUSING DISASSEMBLY

WATER PUMP

REMOVAL

1. Set gear housing in vise in upright position with skeg held between 2 blocks of wood.
2. Remove "O" ring from upper end of drive shaft.
3. Remove rubber centrifugal slinger from drive shaft.
4. Remove one screw and 3 nuts and washers which hold water pump body in place.
5. Use 2 screwdrivers (in slots provided) and pry water pump body from pump base.
6. Remove water pump impeller and impeller drive pin.
7. Remove face plate and 2 gaskets.
8. Pry pump base loose and remove base from drive shaft. Take care not to damage gear housing mating surface with pry tool.
9. Remove pump base to gear housing gasket.

CLEANING and INSPECTION

1. Clean metal parts in solvent and dry with compressed air. DO NOT allow solvent to remain on oil seals, or seals will become unserviceable.

   NOTE: Late drive units do not have oil seal in water pump body.

2. Inspect oil seals in water pump body and pump base for wear, tears, roughness and proper spring positioning. If there is any doubt about oil seal serviceability, replace oil seals.
3. Check surface of drive shaft where oil seal lips contact shaft. Any groove in drive shaft in this area requires oil seals and shaft replacement.
4. Water pump impeller is checked for wear on end of impeller blades and on top and bottom edge of blades. Check bonding between hub and impeller. Blades that have taken a "set" (stay in curved position) should also be replaced.
5. Inspect water pump face plate and insert for roughness and grooves. Replace parts if a defect is found.
6. Check "O" ring for cuts, nicks, hardness and cracks. If "O" ring serviceability is doubtful, replace "O" ring.
7. Always use NEW water pump gaskets.

DISASSEMBLY

1. Remove water tube guide and seal from water pump body assembly.
2. Remove oil seals from water pump housings.

   NOTE: Late drive units do not have oil seal in water pump body.

3. Place pump body on top of open vise and drive insert out of body.
4. Remove "O" ring from pump base.

BEARING CARRIER, REVERSE GEAR, CARRIER RETAINER and TAB WASHER

REMOVAL

1. Straighten tab on bearing carrier retainer tab washer.
2. Loosen bearing carrier retainer by turning counterclockwise with Bearing Carrier Retainer Wrench (C-91-61069). (Figure 1) Remove retainer and tab washer.
3. Use Slide Hammer (C-91-34569A1) with Jaws (C-91-34570) for removing bearing carrier assembly. (Figure 2) The thrust hub may be used to keep puller jaws in place. (Figure 2) Do not lose carrier retaining key.
4. Remove bearing carrier to gear housing shims.

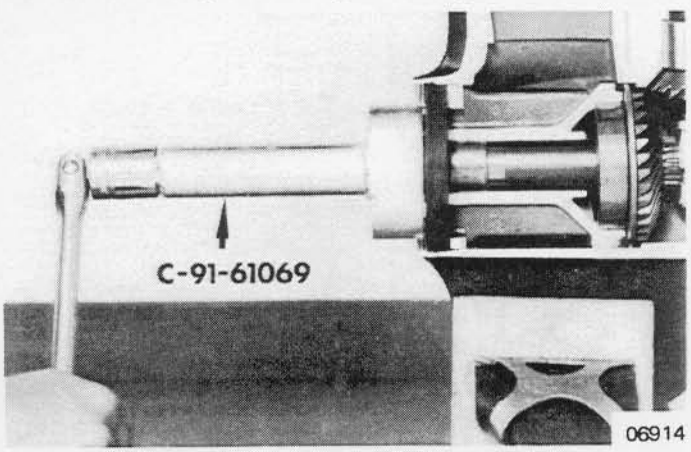

Figure 1. Removing Bearing Carrier Retainer

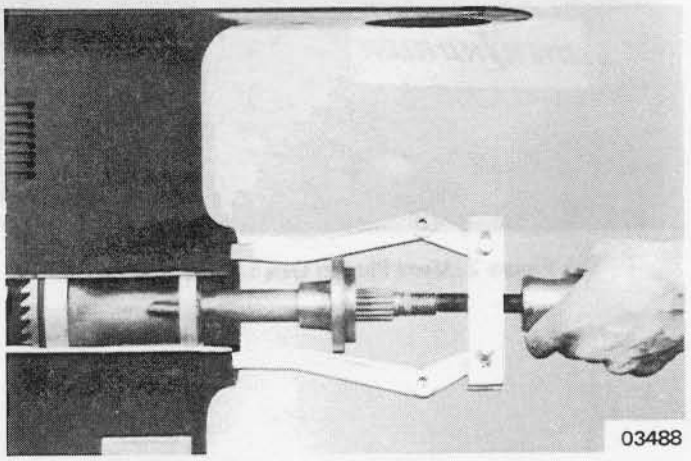

Figure 2. Removing Bearing Carrier

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air. DO NOT allow solvent to remain on oil seals, or seals will become unserviceable.
2. Inspect oil seals for wear, tears, roughness and proper spring position. If oil seal serviceability is doubtful, replace oil seals. Inspect surface of propeller shaft where oil seal lips contact shaft. Any groove in propeller shaft in this area requires oil seals and shaft replacement.

3. Apply a very light coat of oil to reverse gear ball bearing. Rotate bearing and check for rough spots. Grasp reverse gear in one hand and bearing carrier in other. Pull and push to check for side wear. Any excessive movement is cause for replacement.
4. Check roller bearing for serviceability by inspecting bearing contact surface on propeller shaft. Pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles are reason for bearing and propeller shaft replacement.
5. Inspect reverse gear for pitting, chipped or broken teeth and excessive or uneven wear. Check reverse gear clutch engaging surface. Surface must not be chipped or rounded-off.
6. Inspect "O" ring for cuts, nicks, hardness and cracks. If "O" ring serviceability is doubtful, replace "O" ring.
7. Check threaded retainer for cracks and broken or corroded threads.
8. Replace tab washer. DO NOT re-use.
9. Replace all damaged shims with new shim of same thickness.

DISASSEMBLY

IMPORTANT: Clamp only on reinforcing fin of carrier, or carrier may be damaged.

1. Clamp bearing carrier assembly in a vise and use Slide Hammer (C-91-34569A1) to pull reverse gear.
2. Remove "O" ring.
3. Remove ball bearing from reverse gear with Universal Puller Plate (C-91-37241) and arbor press. (Figure 3)

NOTE: If ball bearing remained in bearing carrier, use Slide Hammer to remove bearing.

4. Oil seals can be removed from carrier by prying them out or driving or pulling them out, along with roller bearing.

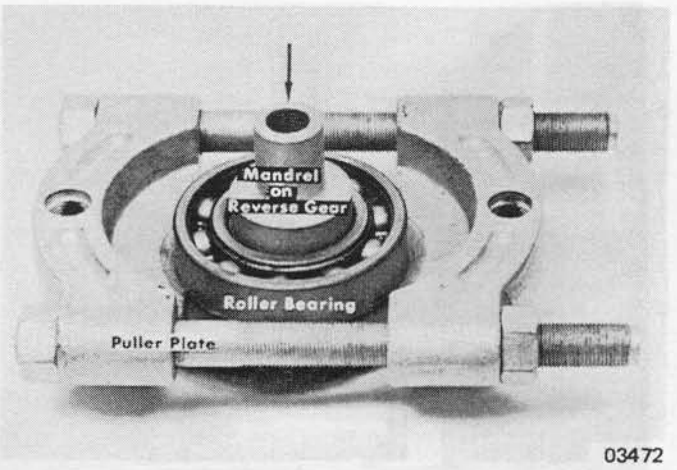

Figure 3. Removing Ball Bearing from Reverse Gear

5. Pull roller bearing from carrier, using Drive Head (C-91-36569) with Bearing Removal and Installation Kit (C-91-31229A4). (Figure 4) Drive Rod (C-91-37323), used in conjunction with arbor press and Drive Head (C-91-36569), also may be used.

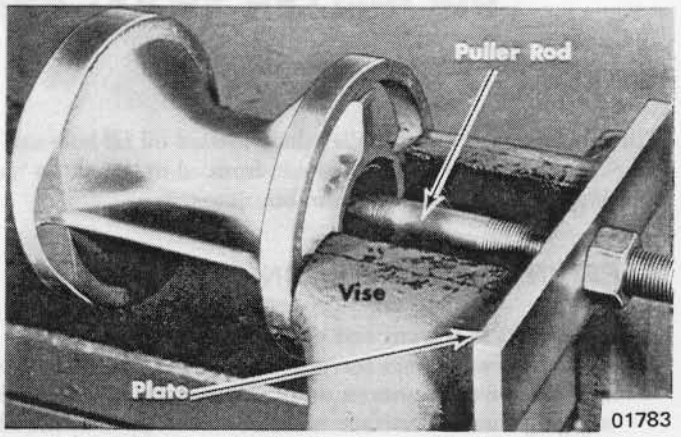

Figure 4. Pulling Roller Bearing and Seals from Carrier

DRIVE SHAFT and PINION GEAR

REMOVAL

1. Install Pinion Nut Adaptor (C-91-61067A1) over propeller shaft and onto pinion gear nut. Turn drive shaft counter-clockwise with Drive Shaft Wrench Adaptor (C-91-56775) to remove nut. (Figure 5)

NOTE: If drive shaft is broken, use small adaptor (part of Pinion Nut Adaptor [C-91-61067A1]) on propeller shaft and turn propeller shaft to loosen pinion gear nut.

2. To remove drive shaft from pinion gear splines, it may be necessary to clamp shaft in a vise (using brass jaws) as close to gear housing as possible. Use block of wood to protect gear housing and drive gear from end of drive shaft as shown in Figure 6.

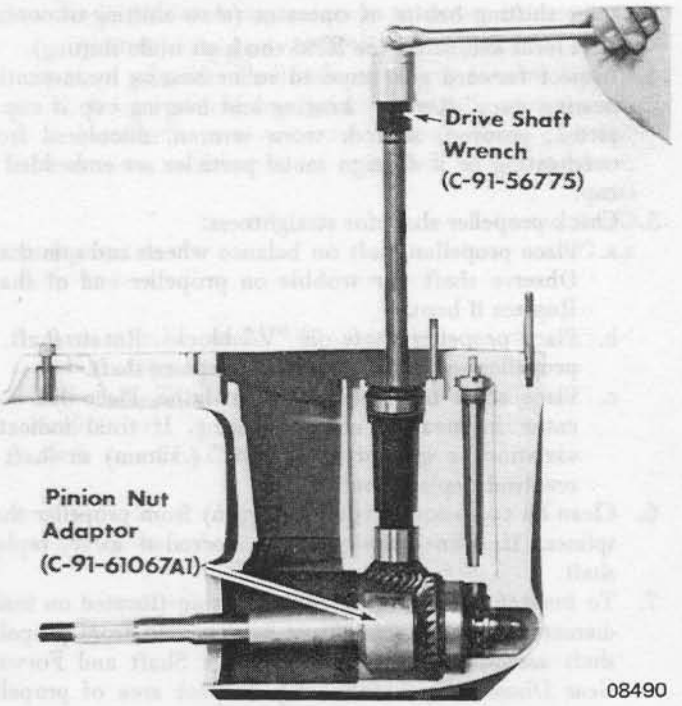

Figure 5. Loosening Pinion Gear Nut

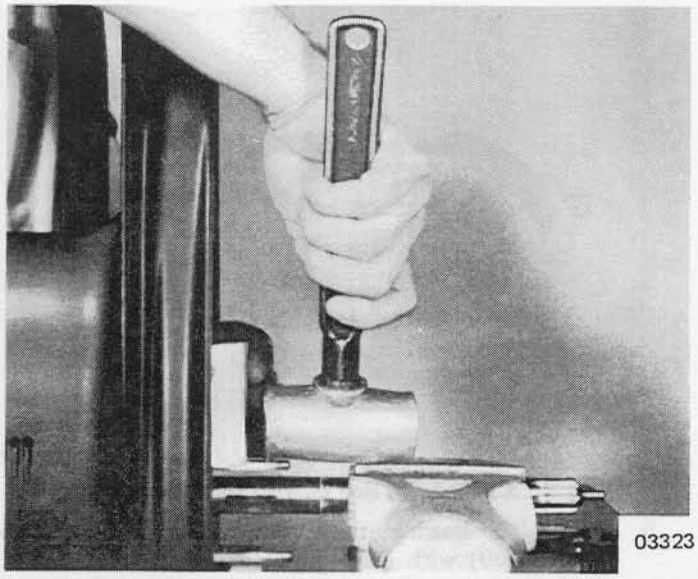

Figure 6. Removing Drive Shaft

CLEANING and INSPECTION

1. Clean in solvent and dry with compressed air.
2. Inspect pinion gear for pitting, chipped or broken teeth and excessive or uneven wear.
3. Inspect area of drive shaft where roller bearing rides. Pitting, grooves, scoring, uneven wear, discoloration from overheating and embedded foreign metal particles are causes for replacement of drive shaft and roller bearing.
4. Check drive shaft tapered roller bearing by inspecting bearing cup. Replace bearing and bearing cup if cup is pitted, grooved, scored, worn uneven, discolored from overheating of if foreign metal particles are embedded in cup.
5. Inspect drive shaft splines (both ends) for wear.
6. If propeller shaft is bent, check drive shaft for straightness.

DISASSEMBLY

Press tapered roller bearing from drive shaft with Universal Puller Plate (C-91-37241) and arbor press.

PROPELLER SHAFT and FORWARD GEAR ASSEMBLY

REMOVAL

Tilt propeller end of propeller shaft toward oil fill hole side of gear housing, disengaging spool from shift crank in gear housing, then lift assembly from housing.

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air.
2. Inspect forward gear for pitting, chipped or broken teeth and excessive or uneven wear. Check forward gear clutch engaging surface. Surface must not be chipped or rounded off.
3. Check sliding clutch engaging surface for chipped or rounded-off condition. Damaged clutch engaging surface indicates incorrect shift cable adjustment, worn parts or poor shifting habits of operator (slow shifting of control shift lever and/or engine RPM too high while shifting).
4. Inspect forward gear tapered roller bearing by inspecting bearing cups. Replace bearing and bearing cup if cup is pitted, grooved, scored, worn uneven, discolored from overheating or if foreign metal particles are embedded in cup.
5. Check propeller shaft for straightness:
   a. Place propeller shaft on balance wheels and spin shaft. Observe shaft for wobble on propeller end of shaft. Replace if bent.
   b. Place propeller shaft on "V" blocks. Rotate shaft. If propeller end of shaft wobbles, replace shaft.
   c. Place shaft between centers in lathe. Place dial indicator in area of needle bearing. If total indicator variation is greater than .005" (.13mm) as shaft is revolved, replace shaft.
6. Clean all corrosion (with wire brush) from propeller shaft splines. If splines are partially corroded away, replace shaft.
7. To inspect forward gear roller bearing (located on inside diameter of gear), gear must be removed from propeller shaft assembly. Refer to "Propeller Shaft and Forward Gear Disassembly", following. Inspect area of propeller shaft where roller bearing rides. Pitting, grooves, scoring, uneven wear, discoloration from overheating and embedded foreign metal particles are all reasons for replacement of bearing and shaft.
8. Check shift spool for wear.

DISASSEMBLY

1. Remove cotter pin from adjusting sleeve and remove sleeve. (Figure 7)

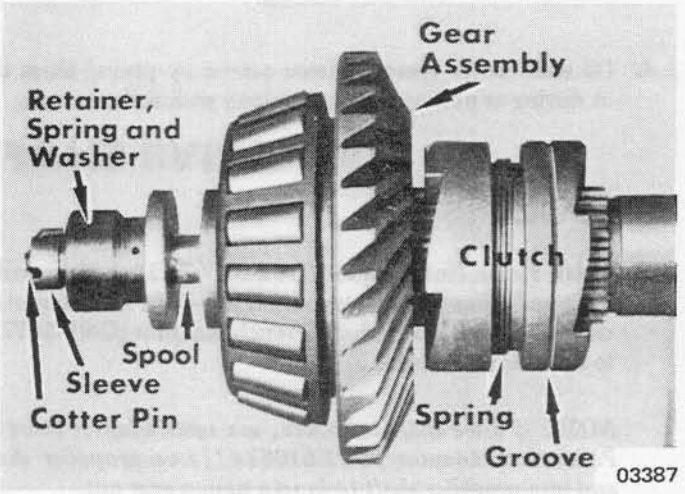

Figure 7. Propeller Shaft Components

2. Spool assembly and forward gear assembly now can be removed from shaft. Remove retainer washers and spring from spool.
3. Press tapered roller bearing from gear with Puller Plate (C-91-37241), proper mandrel and arbor press.
4. Forward gear roller bearing (located on inside diameter of gear) must be broken for removal. Split bearing case with a chisel, then remove bearing.
5. Remove sliding clutch cross pin retaining spring and push cross pin out with a punch. Sliding clutch and clutch actuating shaft now can be removed from propeller shaft. (Figure 7)

SHIFT SHAFT ASSEMBLY

REMOVAL

1. Remove metal washer and rubber washer from shift shaft.
2. Use Shift Shaft Bushing Tool (C-91-31107) to remove shift shaft bushing. (Figure 8)
3. Shift shaft now can be pulled out of gear housing.
4. Shift crank now is loose in gear housing and can be removed from its locating pin.

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air. DO NOT allow solvent to remain on shift shaft bushing oil seal and "O" ring, or seal and "O" ring will become unserviceable.
2. Inspect shift shaft splines (where it engages upper shift shaft) for wear and corrosion.
3. Inspect shift shaft bushing for corrosion damage.
4. Inspect shift shaft bushing oil seal for wear, tears, roughness and proper spring position. Check "O" ring for cuts, nicks, harness and cracks. If "O" ring or oil seal serviceability is doubtful, replace them.
5. Replace shift crank if worn.

DISASSEMBLY

1. Remove oil seal from bushing by driving seal out through top of bushing.

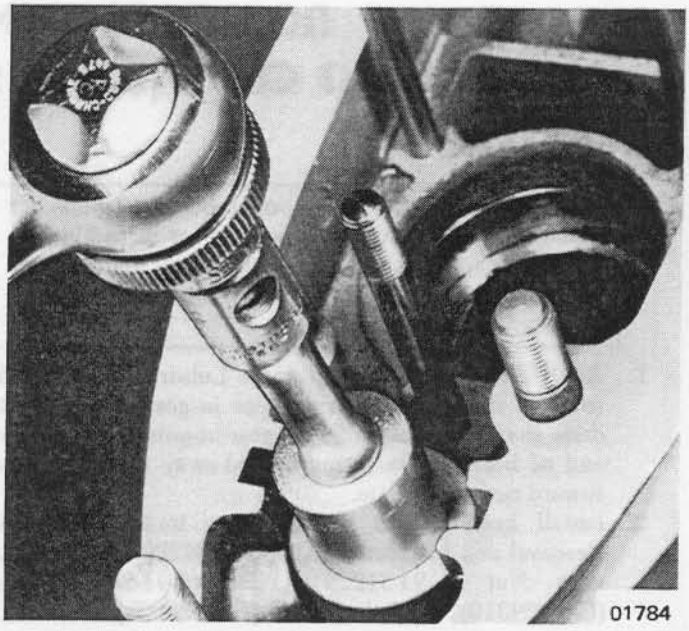

Figure 8. Removing Shift Shaft Bushing

2. Remove "O" ring from bushing.
3. Remove clip from shift shaft.

ROLLER BEARING (DRIVE SHAFT) and BEARING CUPS (DRIVE SHAFT and FORWARD GEAR)

REMOVAL

NOTE: Do not remove drive shaft roller bearing, unless replacement is necessary.

1. Remove drive shaft roller bearing from gear housing with Driver Head (C-91-36569) and Driver Rod (C-91-37323). (Figure 9)
2. Remove drive shaft and forward gear tapered roller bearing cups with Slide Hammer (C-91-34569A1), then remove shims from under cups.

CLEANING and INSPECTION

1. Inspect area of drive shaft where roller bearing rides. Pitting, grooves, scoring, uneven wear, discoloration from overheating and embedded foreign metal particles are causes for replacement of bearing and drive shaft.
2. Check drive shaft and forward gear tapered roller bearing cups by inspecting bearing cups. Replace bearings and bearing cups if cups are pitted, grooved, scored, worn uneven, discolored from overheating or have foreign metal particles embedded in the cup.
3. Replace all damaged shims with new shim of same thickness.

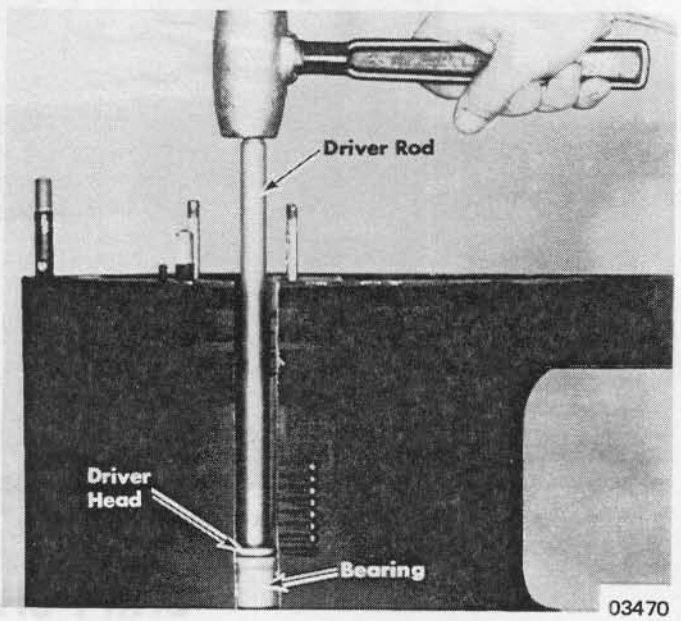

Figure 9. Removing Drive Shaft Roller Bearing

GEAR HOUSING

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air.
2. Check gear housing carefully for impact damage.
3. Check for loose fitting bearing cups and roller bearings.
4. Inspect bearing carrier retainer threads in gear housing for corrosion or stripped threads.
5. Inspect painted surface of gear housing.

GEAR HOUSING REASSEMBLY

ROLLER BEARING (DRIVE SHAFT) and BEARING CUPS (DRIVE SHAFT and FORWARD GEAR)

INSTALLATION

CAUTION: If drive shaft roller bearing failure has occurred, and original bearing case has turned in gear housing, gear housing must be replaced. Loose fitting roller bearings will move out of position and cause repeated failures.

1. Apply thin coat of Multipurpose Lubricant (C-92-63250) to drive shaft roller bearing bore in gear housing. Install drive shaft roller bearing into gear housing with numbered end of bearing case facing up-and-away from pinion gear toward cavitation plate.
2. Install bearing with the following tools from Bearing Removal and Installation Kit (C-91-31229A4): Puller Rod with Nut (C-91-31229), Pilot (C-91-36571), Plate (C-91-29310) and Puller Head (C-91-38628), as shown in Figure 1. Install bearing until bearing bottoms on gear housing shoulder.

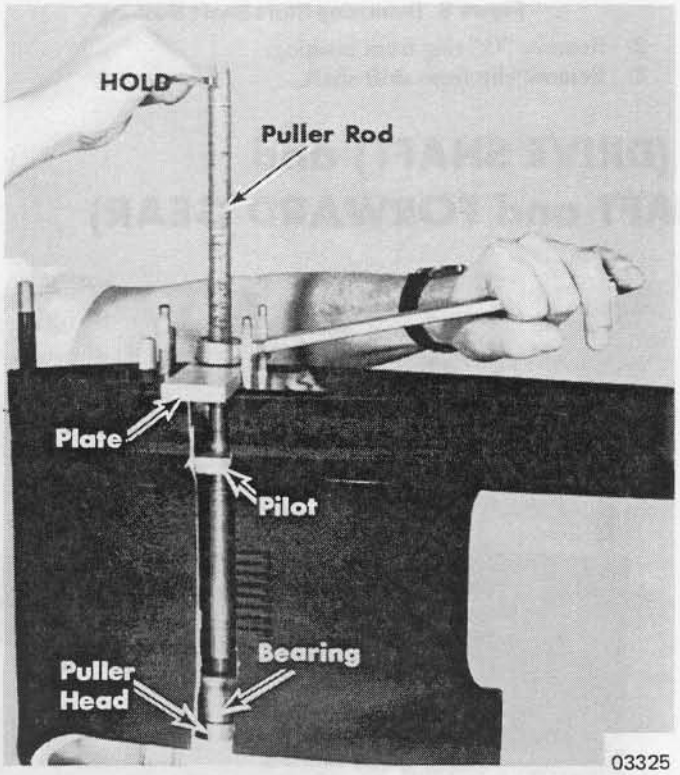

Figure 1. Installing Drive Shaft Bearing

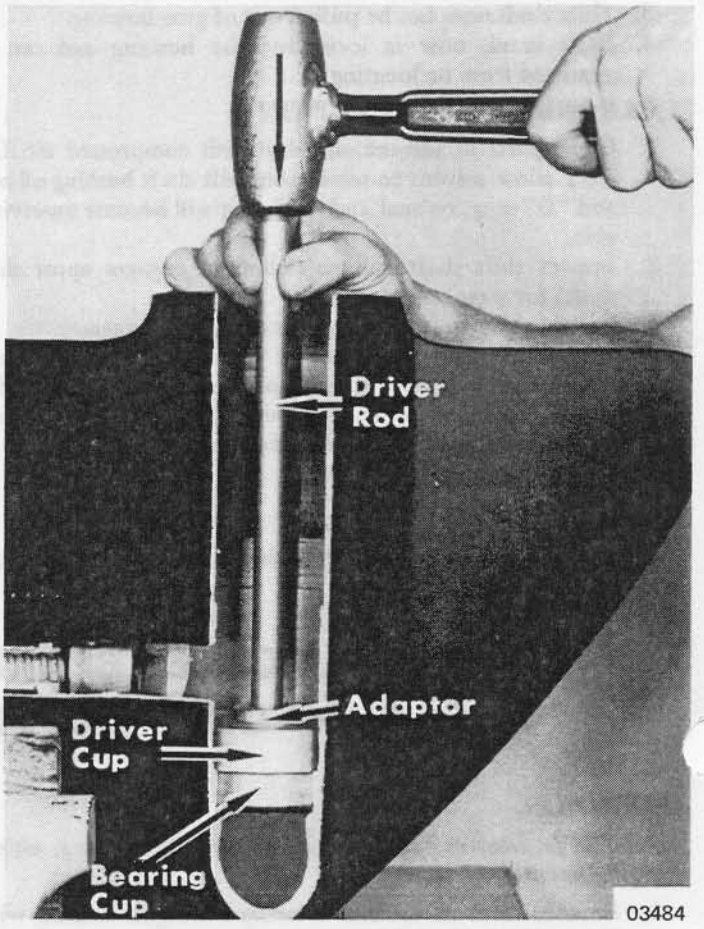

Figure 2. Forward Bearing Cup Installation

3. Place forward gear bearing cup shims in gear housing. Use same thickness of shims that were removed in disassembly.
4. Place bearing cup in gear housing and install cup with Driver Cup (C-91-36577), Driver Rod (C-91-37323) and Adaptor (C-91-37263), as shown in Figure 2.
5. Install drive shaft tapered roller bearing cup and shims in same manner as forward gear bearing cup. Use Driver Cup (C-91-34379), Driver Rod (C-91-37323) and Adaptor (C-91-37263).

SHIFT SHAFT ASSEMBLY

REASSEMBLY

1. Install oil seal in shift shaft bushing.
2. Install "O" ring on shift shaft bushing.
3. Place clip in groove on shift shaft.

INSTALLATION

1. Set shift crank on locating pin, with "throw" side of crank facing oil fill hole side of gear housing.
2. Install shift shaft (with retaining clip) into gear housing, coupling it to shift actuating crank, then place retaining washer over shift shaft on top side of retaining clip.
3. Lubricate lip of oil seal and "O" ring with Multipurpose Lubricant (C-92-63250) to ease installation and install shift shaft bushing. Tighten bushing securely with Tool (C-91-31107).
4. Place rubber washer and upper metal washer on shift shaft. Use Multipurpose Lubricant to hold metal washer in place until gear housing installation is made.

PROPELLER SHAFT and FORWARD GEAR ASSEMBLY

REASSEMBLY

1. Install forward gear roller bearing (located on inside diameter of gear) with a proper adaptor.
2. Press forward gear tapered roller bearing onto forward gear, using suitable adaptor to apply pressing force on center race of bearing. Seat bearing against shoulder of gear.
3. Place first washer, spring and second washer into shift actuating spool, then thread on retainer and tighten.
4. Place sliding clutch on propeller shaft with grooved end of clutch toward reverse gear end of shaft. (Figure 3) Position splines in clutch with shaft so that cross pin holes in clutch and shaft are aligned.
5. Install forward gear and bearing assembly with gear facing sliding clutch.
6. Insert clutch actuating shaft into hole (located in end of propeller shaft). Align hole in actuating shaft to match cross pin holes in sliding clutch and propeller shaft.
7. Insert cross pin through sliding clutch, propeller shaft and actuating shaft.
8. Install cross pin retainer spring around sliding clutch within clutch retainer groove.

CAUTION: Do not over-stretch spring when installing.

9. Slide spool assembly over clutch actuating shaft and thread adjusting sleeve onto shaft until sleeve touches washer and slight resistance is felt. Back off sleeve until next cotter pin slot is aligned with hole in shaft. Install cotter pin. Spool MUST spin freely on shaft.

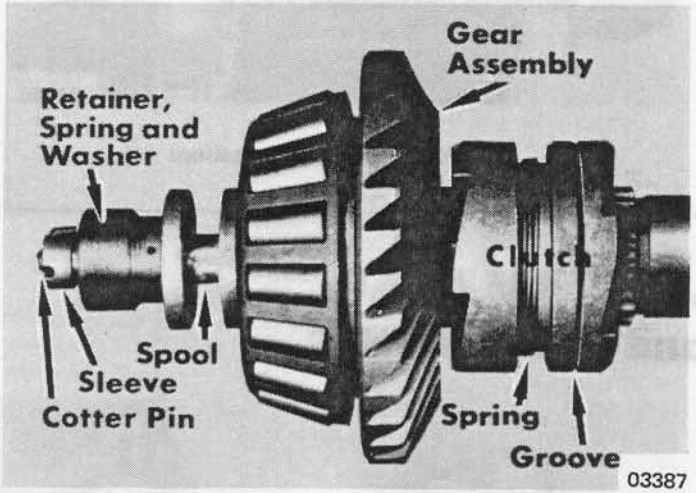

Figure 3. Assembling Propeller Shaft Components

INSTALLATION

Install propeller shaft assembly into gear housing by tilting propeller end of propeller shaft toward oil fill hole side of gear housing. This will allow engagement of shift actuating shaft spool with shift crank. Straighten propeller shaft and operate shift shaft. Sliding clutch ONLY should move when shift shaft is turned, if installation was properly made.

DRIVE SHAFT and PINION GEAR

REASSEMBLY

Press tapered roller bearing on drive shaft with suitable adaptor to apply pressing force on center race of bearing. Seat bearing against shoulder of shaft.

INSTALLATION

1. Place pinion gear into position in gear housing and install drive shaft through pinion gear.
2. Place a drop of Loctite Type "A" (C-92-32609) on pinion gear nut threads and install nut. Torque nut to specifications with Drive Shaft Wrench (C-91-56775) to aid in turning shaft and Pinion Nut Adaptor (C-91-61067A1) to hold nut from turning. (Figure 4)

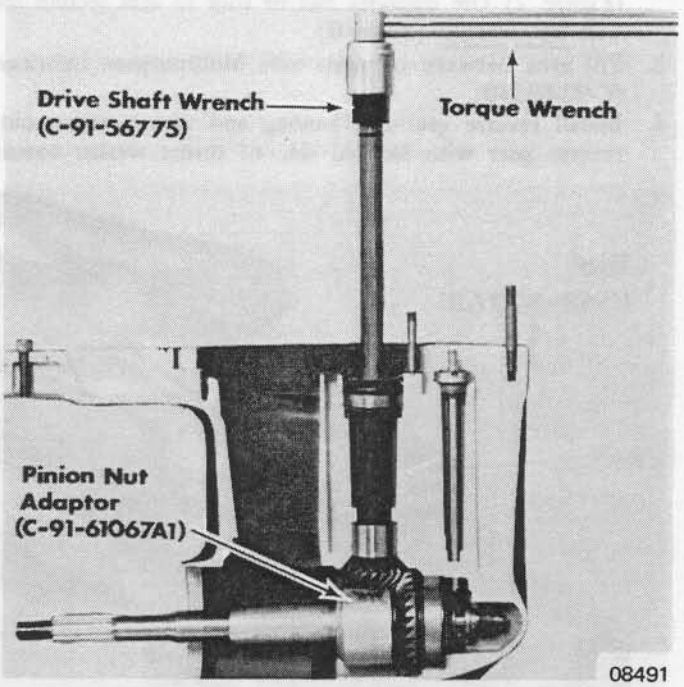

Figure 4. Torquing Pinion Gear Nut

SHIMMING (PINION GEAR)

a. Turn drive shaft to position bearing rollers. Use Pinion Gear Shimming Tool (C-91-56048) and check for .025" (.635mm) clearance between gear and tool while applying inward pressure on drive shaft to seat its roller bearing. (Figure 5)
b. If clearance is not correct, remove pinion gear, drive shaft and bearing cup. If clearance is over .025", remove shims from under bearing cup; if under .025", add shims under bearing cup, then repeat steps No. 1 and 2, immediately preceding.
c. If clearance is correct, continue gear housing reassembly.

NOTE: Pinion Gear Shimming Tool accurately positions pinion gear in gear housing and eliminates misalignment of gear mesh (not gear backlash) between pinion gear and forward and reverse gears. Shimming Tool may be used on earlier MerCruiser 120-140-160-165 gear housings which have late pinion gear (B-43-55812) installed.

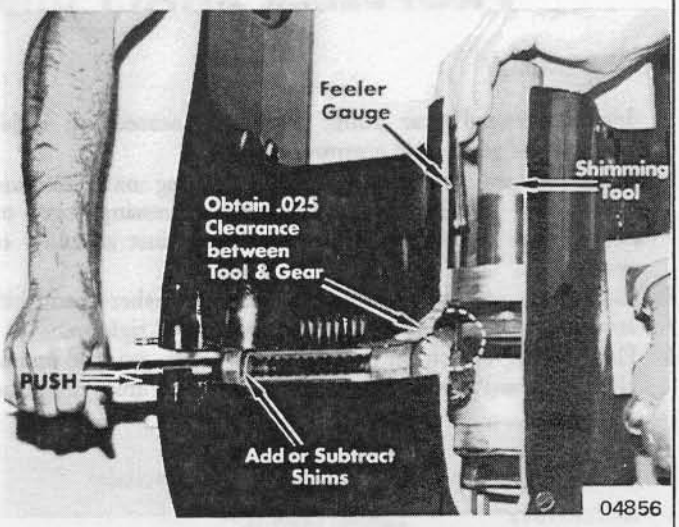

Figure 5. Shimming Procedure

BEARING CARRIER, REVERSE GEAR, CARRIER RETAINER and TAB WASHER

REASSEMBLY

1. Press roller bearing into bearing carrier (Figure 6) with Bearing Driver (C-91-37263) and Driver Rod (C-91-37323).
2. Install oil seals with Loctite Type "A" (C-92-32609) on outside diameter. Use deep shouldered end of Oil Seal Driver (C-91-31108) to install first oil seal with lip in. (Figure 7) Use opposite end of tool to seat second seal with lip outward. (Figure 8)
3. Fill area between oil seals with Multipurpose Lubricant (C-92-63250).
4. Install reverse gear ball bearing and thrust washer onto reverse gear with beveled side of thrust washer toward reverse gear. Use proper mandrel on ball bearing so that pressing force will be applied to inner race of bearing.
5. Press reverse gear and ball bearing assembly into bearing carrier.
6. Install "O" ring between carrier and thrust washer.

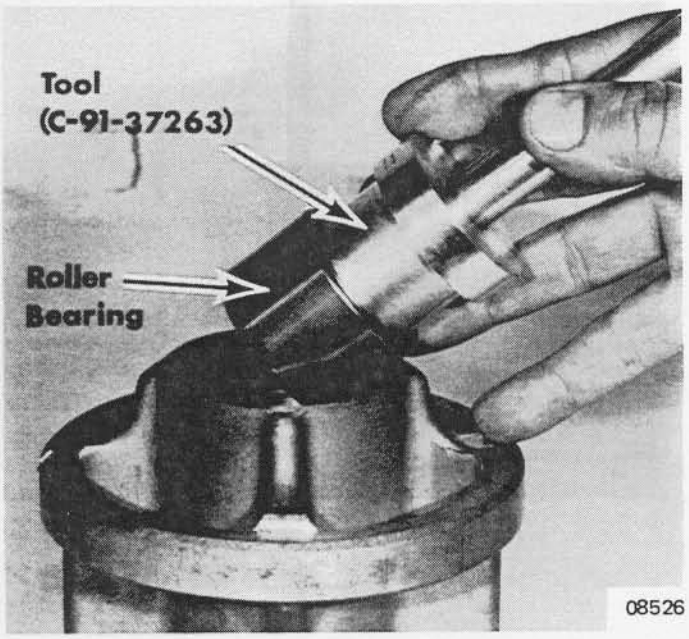

Figure 6. Installing Roller Bearing in Carrier

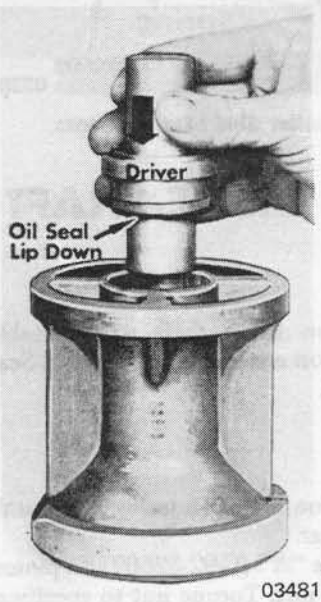

Figure 7. Installing First Oil Seal in Carrier

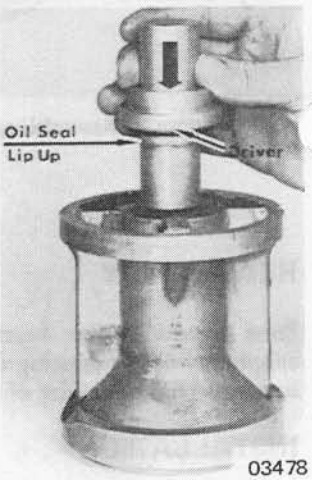

Figure 8. Installing Second Oil Seal in Carrier

INSTALLATION

1. Lubricate carrier "O" ring with Multipurpose Lubricant (C-92-63250).
2. Install shims in gear housing.

IMPORTANT: On final installation of bearing carrier (after forward and reverse gear backlash has been corrected), apply Perfect Seal (C-92-34227) liberally to outer diameters of carrier which contact gear housing. Surfaces

must be clean and oil-free. DO NOT allow sealer to enter ball bearing or reverse gear. Also apply sealer to threads liberally in gear housing before installing retainer.

3. Place bearing carrier assembly into gear housing and push down to seat carrier on shims. It may be necessary to turn drive shaft to align teeth of pinion and reverse gears.
4. Place alignment key in bearing carrier to gear housing keyway.
5. Install bearing carrier retainer tab washer, aligning tab washer "V" tab with "V" notch on bearing carrier.

NOTE: Refer to "IMPORTANT", following Step 2, immediately preceding.

6. Thread bearing carrier retainer into gear housing and torque to specifications in clockwise direction with Bearing Carrier Retainer Wrench (C-91-61069).

NOTE: DO NOT secure carrier retainer with tab washer until forward and reverse gear backlash has been checked and corrected.

SHIMMING (FORWARD AND REVERSE GEAR BACKLASH)

Forward Gear

a. Turn drive shaft clockwise several turns to align rollers in bearings. Fasten dial indicator to gear housing and Backlash Indicator Rod (C-91-53459) to drive shaft. (Figure 9)

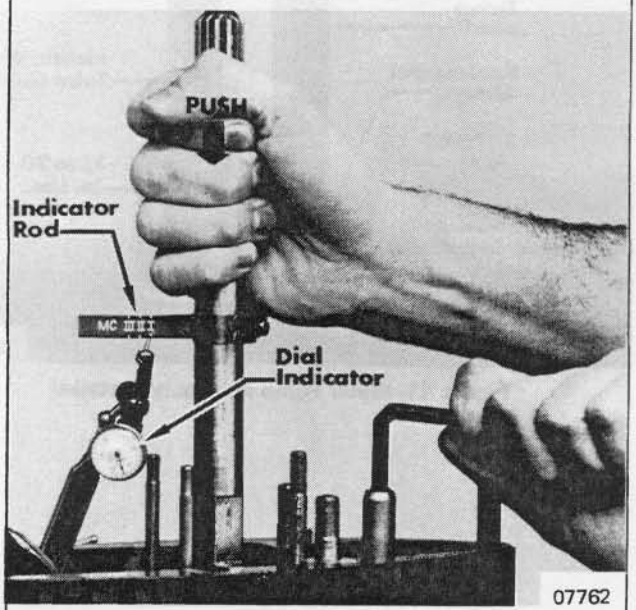

Figure 9. Checking Gear Backlash

b. Shift gear housing into full forward. Turn drive shaft clockwise to ensure full engagement of sliding clutch.
c. Watch shift shaft movement. Slowly turn propeller shaft clockwise until shift shaft movement stops. Apply pressure on shift shaft toward forward gear. This will friction-lock sliding clutch and forward gear as one unit.
d. Position dial indicator pointer to line marked "I" on backlash indicator rod. Hold inward pressure on drive shaft. Lightly turn shaft and pinion gear assembly back-and-forth. DO NOT allow propeller shaft to turn. Dial indicator registers amount of backlash which must be .010" to .012" (.25mm to .30mm). (Figure 9)

NOTE: Both forward and reverse gear backlash should be checked at one time so that changing of shims in either gear may be completed in one disassembly procedure.

e. If backlash is less than required, remove shims from forward gear bearing race. If backlash is more than required, add shims to forward gear bearing race.

Reverse Gear

a. Turn drive shaft clockwise several turns to align rollers in bearings. Fasten dial indicator to gear housing and Backlash Indicator Rod (C-91-53459) to drive shaft. (Figure 9)
b. Shift gear housing into full reverse. Turn drive shaft clockwise to ensure full engagement of sliding clutch.
c. Watch shift shaft movement. Slowly turn propeller shaft counterclockwise until shift shaft movement stops. Apply pressure on shift shaft toward reverse gear. This will friction-lock sliding clutch and reverse gear as one unit.
d. Position dial indicator pointer to line marked "I" on backlash indicator rod. Hold inward pressure on drive shaft. Lightly turn drive shaft and pinion gear assembly back-and-forth. DO NOT allow propeller shaft to turn. Dial indicator registers amount of backlash which must be .020" to .025" (.51mm to .64mm). (Figure 9)
e. If backlash is less than required, add shims between reverse gear thrust washer and gear housing. If backlash is more than required, remove shims.

7. If forward and reverse gear backlash have been checked and shimming has been corrected, repeat steps No. 1-thru-6, immediately preceding.
8. Bend one of the tabs on locking tab washer into one of the slots provided on bearing carrier retainer.

REASSEMBLY

1. Install water pump base smaller oil seal with lip of seal toward impeller side of base.
2. Install larger oil seal with lip of seal toward gear housing.
3. Install "O" ring on water pump base.
4. Press or drive oil seal in pump body with lip facing upward.

NOTE: Late drive units do not have oil seal in water pump body.

5. Coat water pump housing insert (outside diameter) with Perfect Seal (C-92-34227). Install insert into pump body, while exercising care to align tab on insert with hole in pump body. Remove all excess Perfect Seal. DO NOT allow any excess Perfect Seal to remain inside of insert, or impeller will become damaged.
6. Install water tube seal and lubricate inside of seal with Multipurpose Lubricant (C-92-63250), then insert water inlet tube guide.

INSTALLATION

1. Install gasket on water pump base.
2. Lubricate pump base "O" ring and oil seal lips with Multipurpose Lubricant (C-92-63250).
3. Wrap tape around drive shaft "O" ring groove to protect oil seals and slide water pump base over drive shaft and into gear housing.
4. Install lower gasket on water pump base, then face plate (lip down) and upper gasket. (Figure 10)
5. Install impeller drive key in slot provided on drive shaft. Multipurpose Lubricant may be used to hold key in position until pump impeller is installed.
6. Slide impeller over drive shaft and align impeller key slot with key, then seat impeller on face plate.
7. To ease installation, lubricate oil seal lip with Multipurpose Lubricant. Lubricate water pump insert with mixture of soap and water. Place water pump body assembly over impeller and push water pump body down while rotating drive shaft clockwise to help impeller enter pump body.

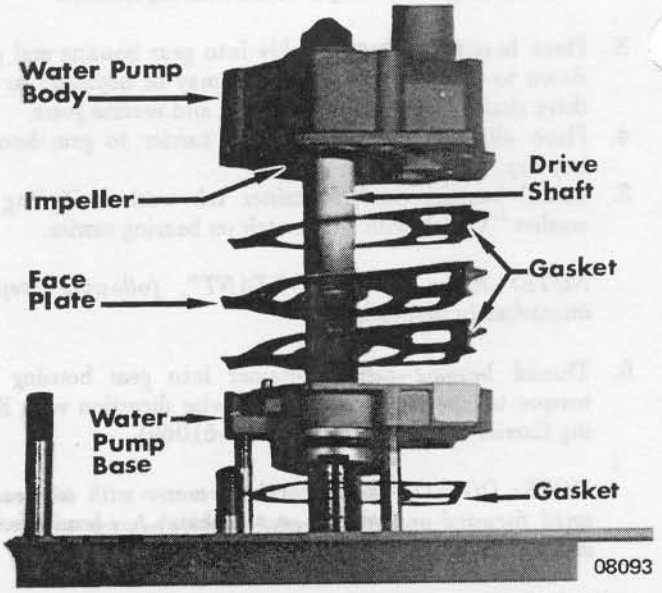

Figure 10. Water Pump Parts Identification

8. Install washers, screw and nuts. Torque screw and nuts to specifications. (Figure 11)

IMPORTANT: Water pump MUST be torqued to specifications, or water pump failure may result.

9. Install centrifugal slinger and drive shaft "O" ring.

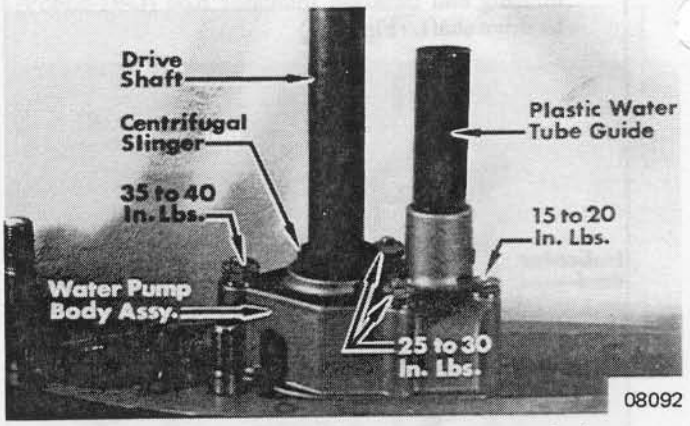

Figure 11. Water Pump Assembly Installed

GEAR HOUSING INSTALLATION

NOTE: If water inlet tube was removed, coat tube upper end with Multipurpose Lubricant (C-92-63250) and install in drive shaft housing.

1. Apply light coat of Multipurpose Lubricant on bottom end of water tube and heavy coat of lubricant on drive shaft splines.
2. Insert allen head trim tab screw in place on top of gear housing.
3. Install seal in groove around gear housing to drive shaft housing inter-connecting oil passage.
4. Shift gear housing assembly into full forward gear.
5. Check that upper shift shaft (located in drive shaft housing) is in full forward position.

NOTE: Gear housing assembly may be held in forward gear by applying slight pressure to propeller shaft in counterclockwise direction.

6. While installing gear housing, align water tube with water tube guide and drive shaft splines with upper drive shaft and shift shaft splines.
7. Rotate propeller shaft counterclockwise to help drive shaft splines enter upper drive shaft splines.

NOTE: If propeller shaft is rotated in clockwise direction before shift shafts are coupled, gear housing must be shifted back into forward gear.

8. With 2 housings joined, install and tighten elastic stop nuts and allen head screw. (Figure 1)
9. Install trim tab and torque allen head screw to specifications, then install plastic plug. (Figure 1)

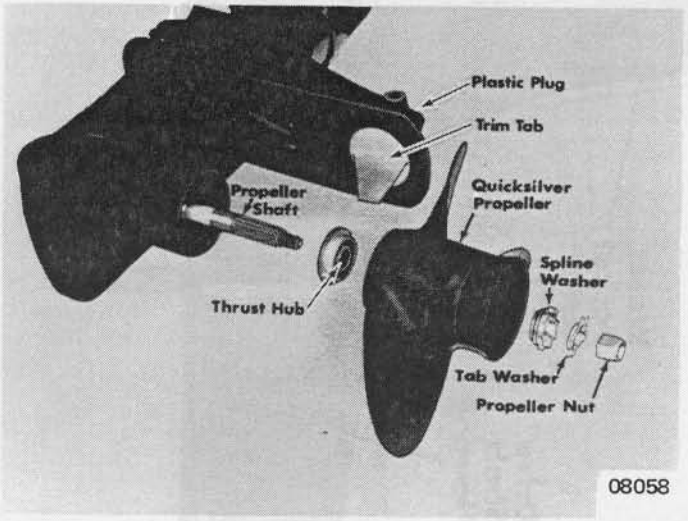

Figure 1. Propeller and Gear Housing Installation

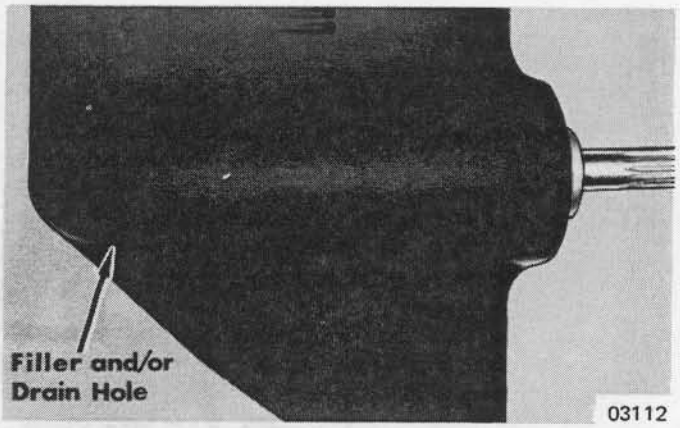

Figure 2. Fill Plug in Gear Housing

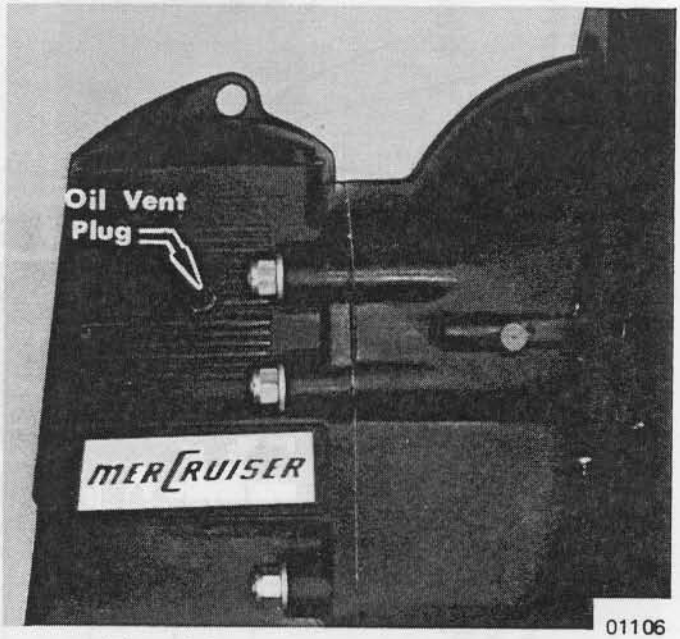

Figure 3. Vent Plug in Drive Shaft Housing

NOTE: Refer to trim tab adjustment in Section 1, "General Information".

10. Install thrust hub, propeller, splined washer, tab washer and propeller nut. (Figure 1)
11. Place block of wood between propeller and anti-cavitation plate to prevent propeller from turning while torquing propeller nut. Bend tab washer tabs into slots provided on splined washer to lock propeller nut.
12. Fill drive unit with Quicksilver Super-Duty Gear Lubricant (C-92-63225) through fill hole in gear housing (Figure 2) until lubricant runs out of vent hole in drive shaft housing. (Figure 3)

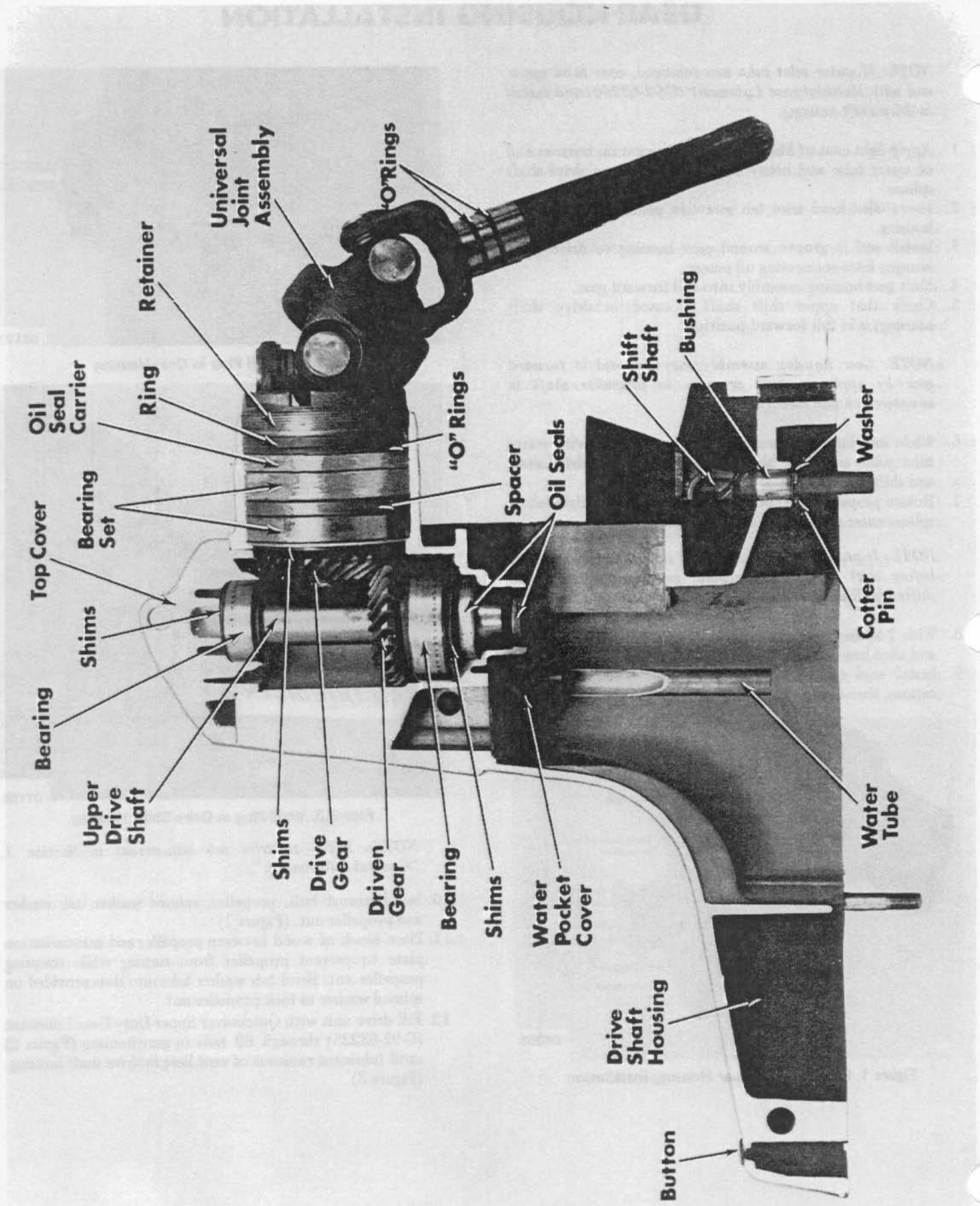

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Figure B. Drive Shaft Housing Parts Identification

DRIVE SHAFT HOUSING REMOVAL

Refer to Section 2, "Removal-Installation-Alignment", for removing drive unit from transom plate assembly.

DRIVE SHAFT HOUSING DISASSEMBLY

Remove gear housing assembly from drive shaft housing. Refer to "Gear Housing Removal" (see "Index").

TOP COVER and WATER POCKET COVER

REMOVAL

1. Remove water tube from water pocket cover.
2. Remove screws from water pocket cover (located inside lower end of drive shaft housing) and remove cover and gasket.
3. Remove 4 screws which hold top cover assembly to drive shaft housing.
4. Remove top cover assembly by lifting and turning cover slightly. (Prying slots are provided.)

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air.
2. Check upper drive shaft top bearing cup (located in top cover) for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cup and bearing, if any of these exist.
3. Inspect top cover "O" ring for cuts, nicks, hardness and cracks. If "O" ring serviceability is doubtful, replace "O" ring.
4. Replace all damaged shims with new shim of same thickness.

DISASSEMBLY

1. Remove upper drive shaft bearing cup from top cover with Slide Hammer Puller (C-91-34569A1).
2. Remove "O" ring from top cover.
3. Remove rubber seal from water pocket cover.

UNIVERSAL JOINT, DRIVE GEAR and BEARING ASSEMBLY

REMOVAL

1. Loosen universal joint tapered roller bearing retainer by turning counterclockwise with Bearing Retainer Wrench (C-91-36235). (Figure 1)
2. Pull straight out on universal joint to remove universal joint, drive gear and bearing assembly.
3. Remove shims which may adhere to bearing cup and/or shoulder in drive shaft housing.

Figure 1. Removing Bearing Retainer

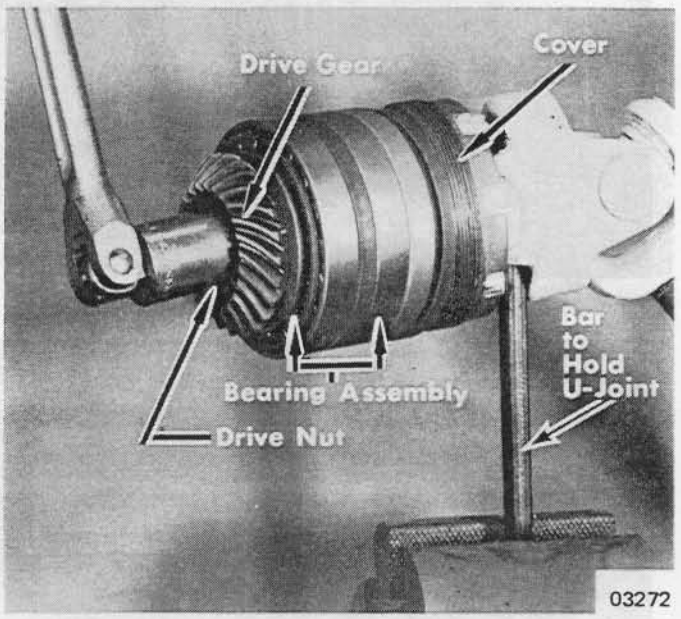


Figure 2. Removing Universal Joint Shaft Nut

DISASSEMBLY

NOTE: Assembly must be disassembled to obtain proper cleaning and inspection.

1. Place one end of suitable bar in vise and other end through universal joint yoke (for holding assembly) and remove nut.
2. Lift drive gear and bearing assembly from universal joint shaft.

CAUTION: DO NOT switch drive gear tapered roller bearings and cups. Bearing must stay with its original bearing cup. Bearings also should be installed on gear in same order as removal. If bearing replacement is necessary, both bearings and small and large spacers must be replaced as an assembly to ensure correct amount of preload when reassembled.

3. Lift retainer ring, "O" ring, oil seal carrier with oil seal, tapered roller bearings and spacers from drive gear.
4. Remove universal joint oil seal from oil seal carrier.
5. Using a punch and hammer, drive off universal joint bearing snap rings. (Figure 3)
6. With suitable adaptor to support universal joint yoke, press on one bearing until opposite bearing is pressed into adaptor. Remove loose bearing. (Figure 4)

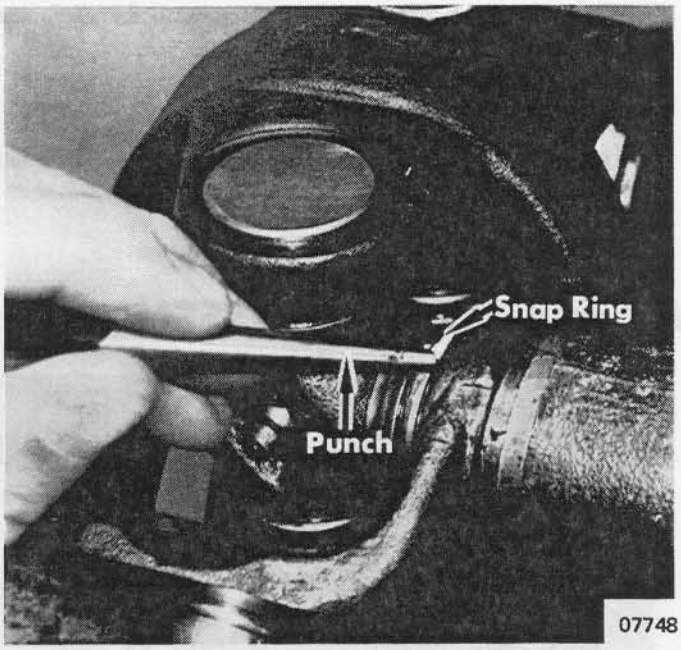


Figure 3. Removing Universal Joint Bearing Snap Rings

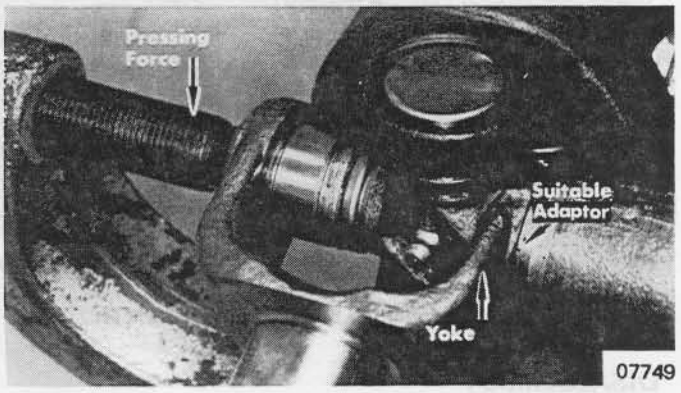


Figure 4. Removing First Universal Joint Bearing

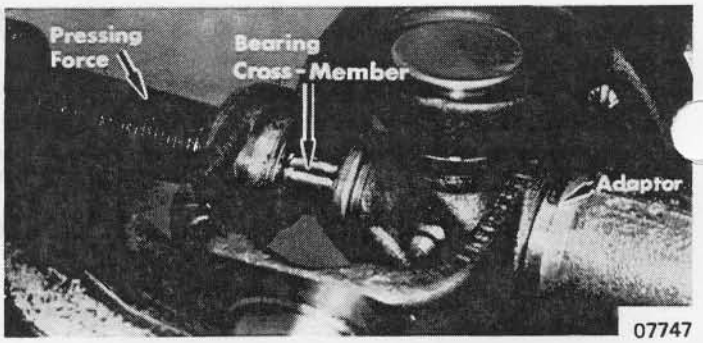


Figure 5. Removing Second Universal Joint Bearing

7. Turn universal joint assembly 180° and press on bearing cross-member to remove second bearing. (Figure 5) Remove each pair of bearings in this manner.
8. Remove 2 "O" rings from coupling end of universal joint shaft.

CLEANING and INSPECTION

1. Clean all parts in solvent and dry with compressed air.
2. Inspect splines on both coupling and gear end of universal joint assembly for wear.
3. Clean all corrosion from coupling end. If splines are partially corroded away, replace (coupling end) yoke.

NOTE: If universal joint coupling end splines are corroded or worn, also inspect engine coupling splines. Lubricate universal joint spline and engine coupling splines with Multipurpose Lubricant (C-92-63250) before drive unit installation.

4. Inspect shaft (between yoke and splines) on gear end of universal joint for groove were oil seal rides. If shaft is grooved, install NEW oil seal and NEW yoke on universal joint.
5. Check universal joint bearings for excessive looseness. If bearings are worn or pitted from presence of water in bellows, replace cross and bearing assemblies.

CAUTION: Use only Universal Joint Lubricant (C-92-68409) for lubricating universal joint bearings.

6. Inspect drive gear for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear if any of these exist.
7. Check tapered roller bearings by inspecting bearing cups. Replace bearings and bearing cups if cups are pitted, grooved, scored, worn uneven, discolored from overheating or have foreign metal particles embedded in cup.
8. Inspect oil seal for wear, tears, roughness and proper spring position. If oil seal serviceability is doubtful, replace oil seal.
9. Inspect "O" rings for cuts, nicks, hardness and cracks. If "O" ring serviceability is questionable, replace "O" ring.
10. Replace all damaged shims with new shims of same thickness.

UPPER DRIVE SHAFT and DRIVEN GEAR ASSEMBLY

REMOVAL

Lift upper drive shaft and gear assembly from drive shaft housing.

CLEANING and INSPECTION

1. Inspect driven gear for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear if any of these exist.

2. Replace tapered roller bearings and bearing cups if cups are pitted, grooved, scored, worn uneven, discolored from overheating or have foreign metal particles embedded in the cup.
3. Inspect surface of driven gear shaft where oil seal lip contacts the shaft. Any groove in shaft in this area requires oil seal and gear replacement.

DISASSEMBLY

CAUTION: DO NOT remove bearings unless replacement is necessary.

1. Use Universal Puller Plate (C-91-37241) and arbor press to remove tapered roller bearing from driven gear. (Figure 6)

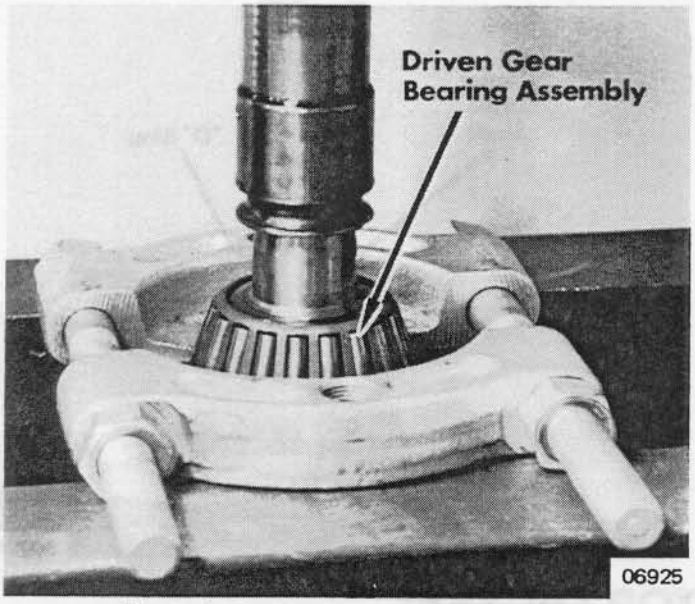


Figure 6. Removing Driven Gear Bearing

2. With Universal Puller Plate (C-91-37241) placed under upper drive shaft bearing and using an appropriate tool, press bearing from drive shaft on an arbor press. (Figure 7)
3. Support driven gear with Universal Puller Plate or proper tool, and press upper drive shaft from driven gear with appropriate tool. (Figure 8)
4. Remove "O" ring from lower end of upper drive shaft.

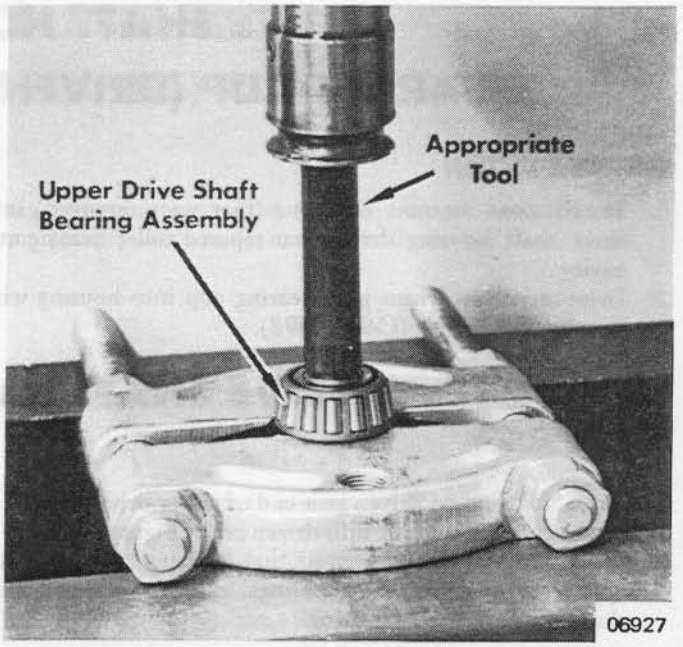


Figure 7. Removing Upper Drive Shaft Bearing

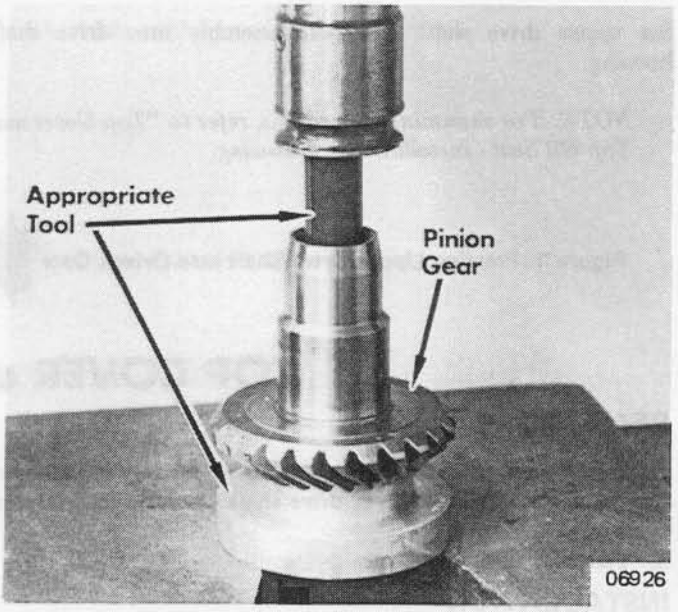


Figure 8. Removing Upper Drive Shaft from Driven Gear

BEARING CUP (DRIVEN GEAR) and OIL SEALS

CLEANING and INSPECTION

1. Inspect oil seals for wear, tears, roughness and proper spring position. If oil seal serviceability is doubtful, replace oil seals.
2. Check bearing cup for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cup and bearing if any of these exist.

REMOVAL

1. Use Slide Hammer Puller (C-91-34569A1) to remove driven gear bearing cup and oil seals.
2. Remove driven gear bearing cup shims.

INTERMEDIATE SHIFT SHAFT

REMOVAL

1. Remove intermediate shift shaft retaining cotter pin and washer, then remove shift shaft.
2. Drive out shift shaft bushing, if replacement is necessary.

INSPECTION

Check shift shaft for bent condition. Shift shaft may be bent if installation of drive unit is attempted without drive unit shifted into forward gear position.

DRIVE SHAFT HOUSING

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air.
2. Check housing carefully for impact damage.
3. Check for loose fitting bearing cups.
4. Inspect condition of housing painted surface.

DRIVE SHAFT HOUSING REASSEMBLY
BEARING CUP (DRIVEN GEAR) and LOWER OIL SEAL

INSTALLATION

1. Install same amount of shims (that were removed) into drive shaft housing driven gear tapered roller bearing cup cavity.
2. Drive or press driven gear bearing cup into housing with Bearing Cup Driver (C-91-33493).
3. Install lower drive shaft housing oil seal with lip facing driven gear.

NOTE: DO NOT install upper oil seal until upper drive shaft preload is set.

UPPER DRIVE SHAFT and DRIVEN GEAR ASSEMBLY

REASSEMBLY

1. Place "O" ring on driven gear end of upper drive shaft.
2. Press upper drive shaft into driven gear. (Figure 1)
3. Use appropriate adaptor, so that pressing force will be applied to inner race of bearings, and install upper drive shaft and driven gear bearing.

INSTALLATION

Set upper drive shaft and gear assembly into drive shaft housing.

NOTE: For shimming procedures, refer to "Top Cover and Top Oil Seal - Installation", following.

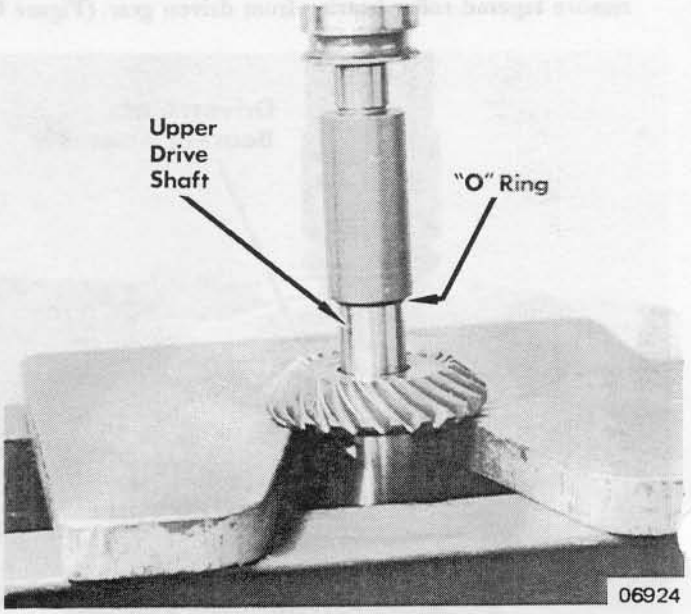


Figure 1. Pressing Upper Drive Shaft into Driven Gear

TOP COVER and TOP OIL SEAL

REASSEMBLY

1. Install same amount of shims (that were removed) into top cover, then install upper drive shaft tapered roller bearing cup.
2. Place "O" ring on cover.

INSTALLATION

1. Install cover assembly on drive shaft housing and torque 4 holding screws to specifications while turning shaft. (Correct top cover torque is important to ensure proper bearing preload.)

SHIMMING (UPPER DRIVE SHAFT BEARING PRELOAD)

a. Insert gear housing drive shaft (with pinion gear nut installed) into upper drive shaft splines. (Figure 2) Use an in. lb. torque wrench (C-91-66274) to check upper drive shaft bearing preload at 6 to 10 in. lbs. (6.9 to 11.5kg-cm).

b. If reading is too high, shims must be removed from under bearing cup in top cover. If reading is less than specified, shims must be added under bearing cup to obtain proper preload.

NOTE: If shim thickness in top cover is changed, top cover again must be torqued before re-measuring drive shaft bearing preload.

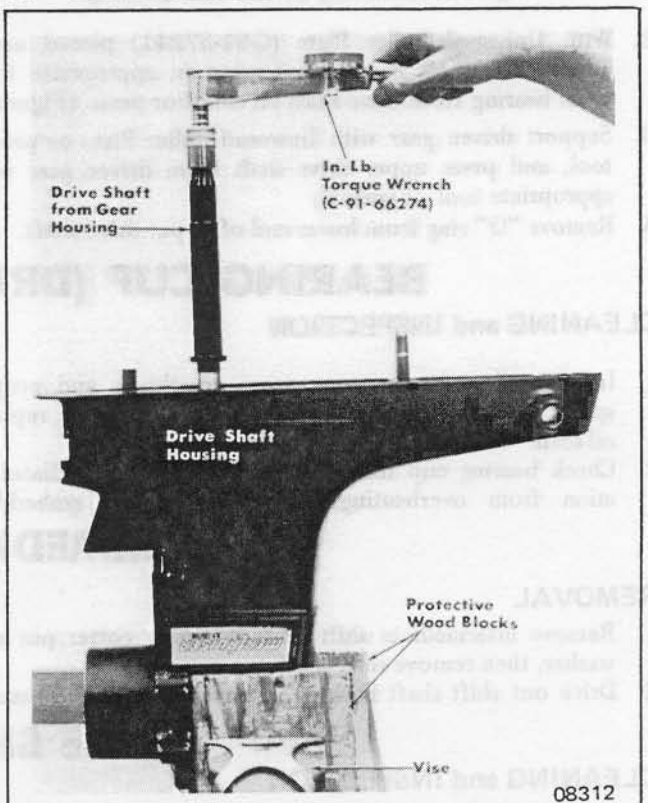


Figure 2. Determining Preload on Upper Drive Shaft

2. With bearing preload correct, top oil seal may be installed with lip facing toward driven gear. Use Oil Seal Driver (C-91-33490).

SHIMMING (DRIVEN GEAR)

a. With bearing preload correct and top cover torqued to specifications, place Shimming Tool (C-91-60526) into drive gear and bearing assembly cavity. (Figure 3) See chart (following) for correct position of shimming tool to be used.

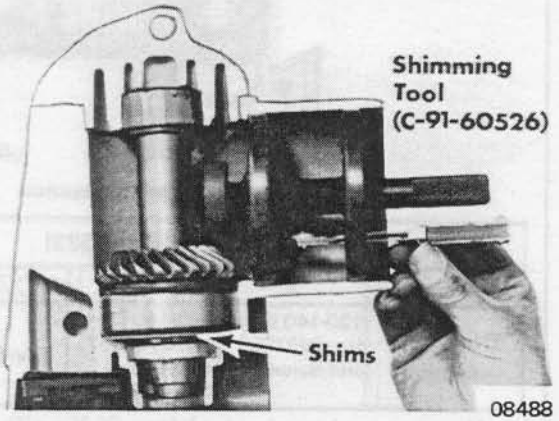


Figure 3. Measuring Driven Gear Clearance

SHIMMING TOOL (C-91-60526)			
Tool Position	X	Y	Z
Drive Unit Model	165	120-140 -470	V-8's

b. Align proper shimming tool face (X-Y or Z) with 2 or 3 teeth (depending upon gear ratio) of driven gear. Insert feeler gauge (.025" [.64mm]) between one outside tooth of aligned gear teeth and shimming tool. Rotate shimming tool to obtain light drag on feeler gauge. Then (without moving shimming tool), insert feeler gauge between shimming tool and other outside tooth of aligned gear teeth.

c. If clearance is larger than feeler gauge being used, repeat preceding procedure (Step "b"), using thicker feeler gauge until same clearance is obtained between both outside gear teeth and tool.

d. If clearance is smaller than feeler gauge being used, repeat preceding procedure (Step "b"), using thinner feeler gauge until same clearance is obtained between both outside gear teeth and tool.

NOTE: The preceding procedure will position shimming tool face parallel with face of gear and obtain correct reading of clearance between gear and shimming tool.

e. Correct clearance is .025" (.64mm). If clearance on gear being checked is less than .025", subtract clearance reading, that you have, from .025" and remove shims of that thickness from under driven gear tapered roller bearing cup. Also add shims of same thickness under upper drive shaft tapered roller bearing cup to maintain bearing preload. Recheck clearance.

f. If clearance is more than .025", subtract .025" from clearance reading, that you have, and add shims of that thickness under driven gear tapered roller bearing cup. Also remove shims of same thickness under upper drive shaft tapered roller bearing cup to maintain bearing preload. Recheck clearance.

UNIVERSAL JOINT, DRIVE GEAR and BEARING ASSEMBLY

REASSEMBLY

IMPORTANT: Use only Universal Joint Lubricant (C-92-58229) for lubricating universal joint bearings.

1. Place universal joint bearing cups in yoke and start them on bearing cross-members. Finish installation by pressing bearings through yoke and onto cross-members. (Figure 4)
2. Install bearing cup retaining snap rings. (Figure 5)

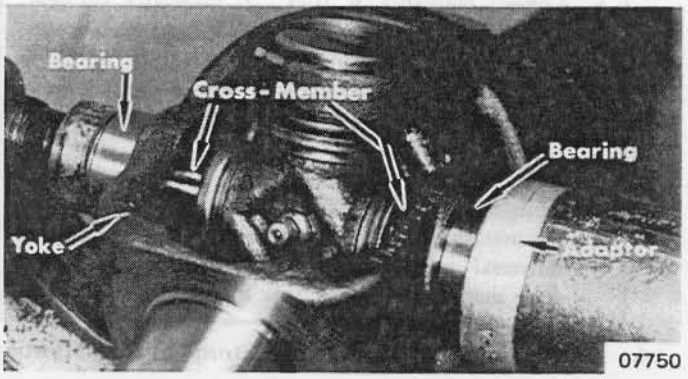


Figure 4. Installing Universal Joint Bearings

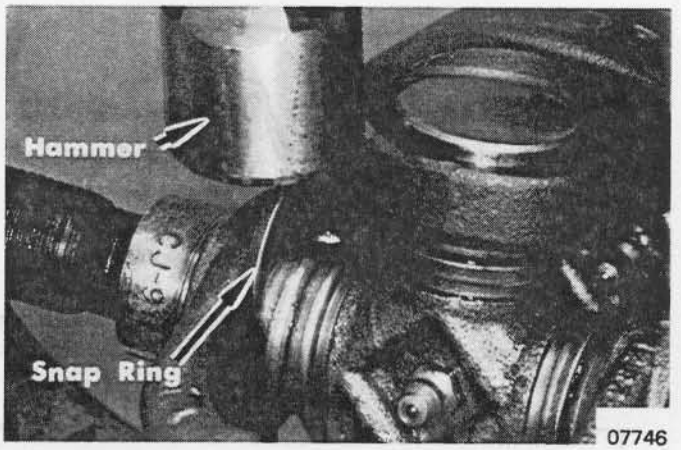


Figure 5. Installing Bearing Cup Snap Rings

3. Install each pair of bearings in this manner.
4. Install two "O" rings in grooves provided on coupling end of universal joint shaft.
5. Press oil seal into oil seal carrier (with lip of seal facing concave side of carrier) until seal is flush with carrier. Lubricate lip of seal with Multipurpose Lubricant (C-92-63250).

6. Place tapered roller bearing on gear, small and large spacer, second tapered roller bearing, oil seal carrier assembly, "O" ring and ring. (Figure 6)

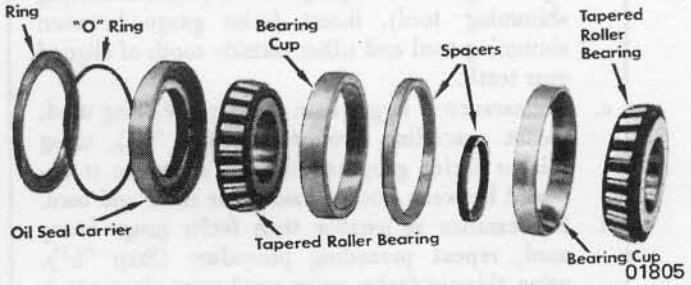


Figure 6. Bearing Set Parts Identification

7. Place one end of suitable bar in vise and other end through universal joint yoke for holding. Place bearing retainer nut, drive gear and bearing assembly onto universal joint assembly. Place washer (concave side facing drive gear) and nut on universal joint shaft. Be sure that preload spacer is centered and does not protrude past bearing cups. Torque nut to specifications while turning bearings.

NOTE: The torque on universal joint shaft nut applies correct preload on drive gear bearing assembly. Make sure that torque is correct.

INSTALLATION

1. Remove top cover assembly.
2. Place universal joint tapered roller bearing cup to drive shaft housing shims into housing cavity.

CAUTION: MerCruiser drive units with same number of teeth on both gears (in drive shaft housing) have identification marks on drive and driven gears. These marks must be matched as shown in Figure 7, whenever gears are installed into drive shaft housing.

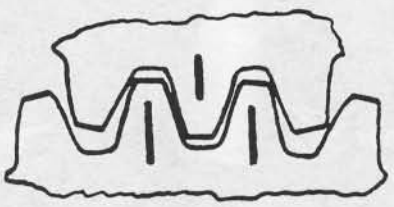


Figure 7. Matching Gear Identification Marks

3. Install universal joint and drive gear assembly into drive shaft housing. Torque bearing retainer nut to specifications.

SHIMMING (DRIVE GEAR)

a. Place Shimming Tool (C-91-60523) into drive shaft housing top cover cavity. (Figure 8) See chart (following) for correct position of shimming tool to be used.

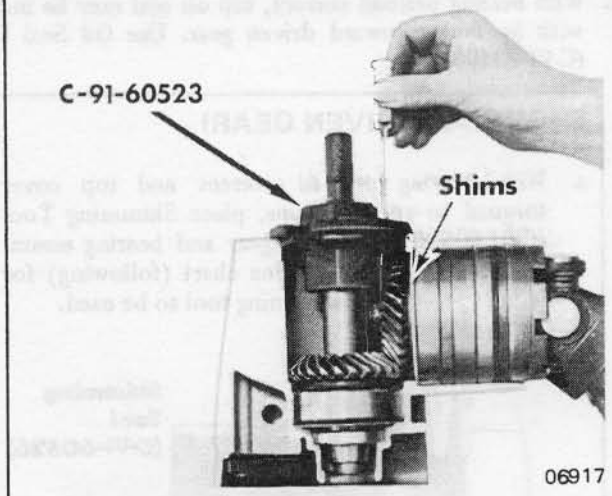


Figure 8. Measuring Drive Gear Clearance

SHIMMING TOOL (C-91-60523)			
Tool Position	X	Y	Z
Drive Unit Model	120-140 (Serial No. 2791956 and Below)	120-140 (Serial No. 2791957 and Above) 165 and 470	V-8's

b. Align proper shimming tool face (X-Y or Z) with 2 or 3 teeth (depending upon gear ratio) of driven gear. Insert feeler gauge (.025" [.64mm]) between one outside tooth of aligned gear teeth and shimming tool. Rotate shimming tool to obtain light drag on feeler gauge, then (without moving shimming tool) insert feeler gauge between shimming tool and other outside tooth of aligned gear teeth.

c. If clearance is larger than feeler gauge, which is being used, repeat preceding procedure (Step "b"), using thicker feeler gauge until same clearance is obtained between both outside gear teeth and tool.

d. If clearance is smaller than feeler gauge (being used), repeat preceding procedure (Step "b"), using thinner feeler gauge until same clearance is obtained between both outside gear teeth and tool.

NOTE: The preceding procedure will position shimming tool face parallel with face of gear and obtain correct reading of clearance between gear and shimming tool.

e. Correct clearance is .025". If clearance on gear being checked is less than .025", subtract clearance reading, that you have, from .025" and add shims of that thickness between universal joint tapered roller bearing cup and drive shaft housing. Recheck clearance.

f. If clearance is more than .025", subtract .025" from clearance reading, that you have, and remove shims of that thickness from between universal joint tapered roller bearing cup and drive shaft housing. Recheck clearance.

4. Reinstall top cover assembly and torque to specifications.

INTERMEDIATE SHIFT SHAFT

INSTALLATION

1. Drive shift shaft bushing into drive shaft housing.
2. Place shift shaft thru bushing and install washer and cotter pin.

WATER POCKET COVER

REASSEMBLY

Install rubber seal in water pocket cover. Lubricate seal with Multipurpose Lubricant (C-92-63250).

INSTALLATION

1. Place NEW gasket and water pocket cover in position on drive shaft housing.
2. Install screws and torque to specifications.

DRIVE SHAFT HOUSING INSTALLATION

1. Install gear housing assembly onto drive shaft housing, following instructions under "Gear Housing Installation" (see "Index").
2. To install drive shaft housing to transom plate assembly, refer to Section 2, "Removal-Installation-Alignment".

HYDRAULIC POWER TRIM TRANSOM PLATE ASSEMBLY
Without Side-Mounted Rotary Switch (Figure A)

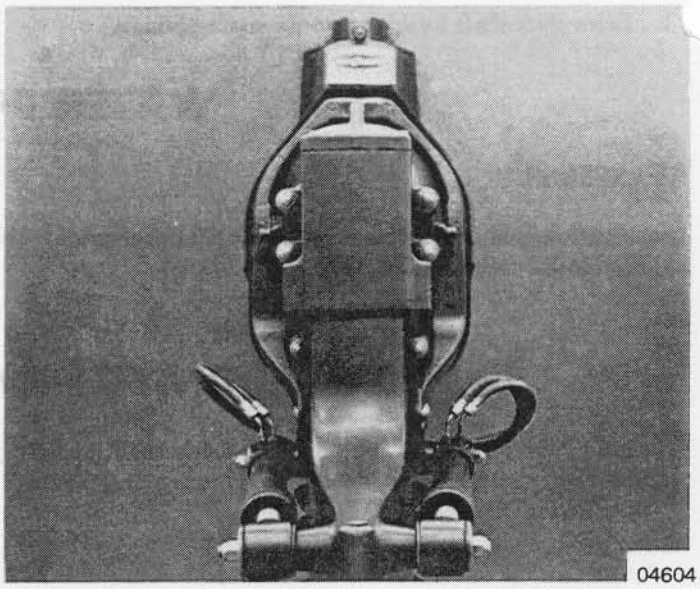


Figure A.
Transom Plate
and Drive
without Side-Mounted
Rotary Switches

GIMBAL HOUSING BALL BEARING

INSPECTION

1. Remove drive unit from bell housing, as outlined in "Removal", Section 2.
2. Reach thru bell housing and rotate bearing to check for rough spots. Pull and push on inner race to check for side wear. Any excessive movement is cause for replacement.

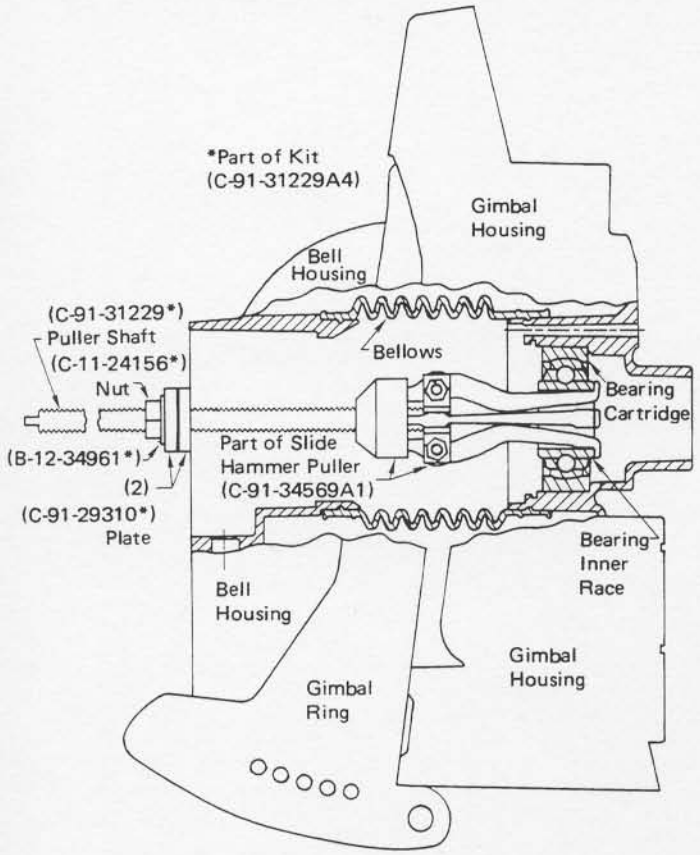


Figure 1. Removing Bearing Cartridge Assembly

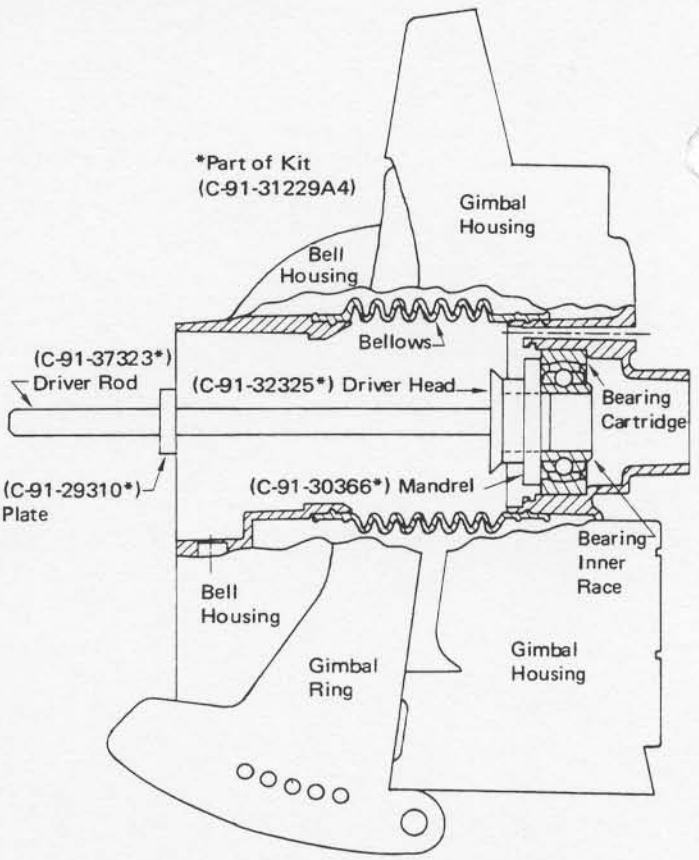


Figure 2. Installing Bearing Cartridge Assembly

REMOVAL

CAUTION: Gimbal bearing may be damaged during removal. Do not remove bearing cartridge assembly unless replacement is necessary.
Replacement bearings come as an assembly with cartridge and must be replaced as an assembly.

1. Remove drive unit from bell housing as outlined in "Removal" Section 2.
2. Remove snap ring (if installed) with Ring Pliers (C-91-37240A1).
3. Remove bearing cartridge assembly with tools illustrated in Figure 1. Two (2) plates (C-91-29310) must be used. Position plates between top and middle studs (located on bell housing). Use 3-jaw puller from Slide Hammer Puller (C-91-34569A1).
   If bearing assembly is very tight, it may be necessary to tap end of Puller Shaft C-91-31229) with a mallet while turning nut (C-11-24156).

   NOTE: Older Bearing Removal and Installing Kits (C-91-31229A4) will need 5/8-18 threads cut in unthreaded portion of Puller Shaft (C-91-31229) to accept slide hammer 3-jaw puller and jaw spreader adaptor.

INSTALLATION

1. Lubricate outside of cartridge gimbal bearing assembly with Quicksilver Multipurpose Lubricant (C-92-63250).
2. Install bearing cartridge assembly with tools illustrated in Figure 3.
3. Insert Driver Head (C-91-32325) thru Mandrel (C-91-30366) and into inside diameter of bearing assembly.
4. Align bearing cartridge assembly with gimbal housing cavity. Place Plate (C-91-29310) between top and middle studs (on bell housing) as a pilot. Drive bearing cartridge assembly into gimbal housing cavity with a lead hammer or mallet.
5. Lubricate cartridge gimbal bearing with Pistoluber (C-91-37299), using ONLY Quicksilver Multipurpose Lubricant (C-92-63250) thru grease fitting. Pump 40 full strokes (1 oz.) to adequately lubricate bearing.
6. Install snap ring. If gimbal bearing (B-30-60794A2, with tolerance ring) is installed, snap ring can be omitted.

   NOTE: Use Engine Alignment Shaft (C-91-48247 or C-91-57797A3) to align gimbal bearing after installation and check engine alignment.

7. Install drive unit as outlined in "Installation", Section 2.

TILT STOP SWITCH ASSEMBLY

TESTING

With drive unit in the "Down" position, connect continuity meter or test lamp to switch leads. Meter should show continuity or lamp lights. Run Power Trim in "UP" direction until tilt stop switch is actuated. Meter should show NO continuity or lamp should NOT light. Replace switch if defective.

REMOVAL

1. Disconnect steering link rod from steering lever. (Figure 3)
2. Support drive unit with an overhead hoist and remove 2 gimbal ring to bell housing hinge pins.

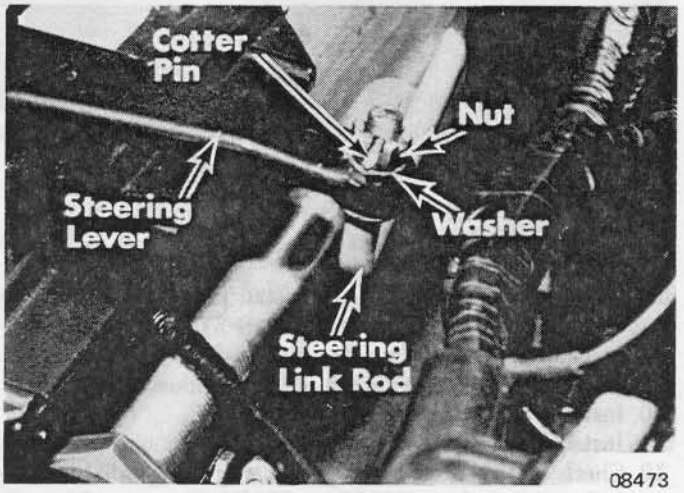


Figure 3. Steering Lever and Link Rod

3. Operate Power Trim in "up" direction (approximately 5" [12.7cm] cylinder ram movement) and pull bell housing and drive unit assembly away from gimbal housing as far as bellows will allow.

CAUTION: Be careful not to damage gimbal ring roller bearing when driving lower swivel pin with punch.

4. Remove cotter pin from lower swivel pin. (Figure 4) Drive swivel pin down with punch and hammer until cotter pin hole is protruding from gimbal housing. Then, insert small punch or like-object into cotter pin hole (one from each side) and pull pin from housing.

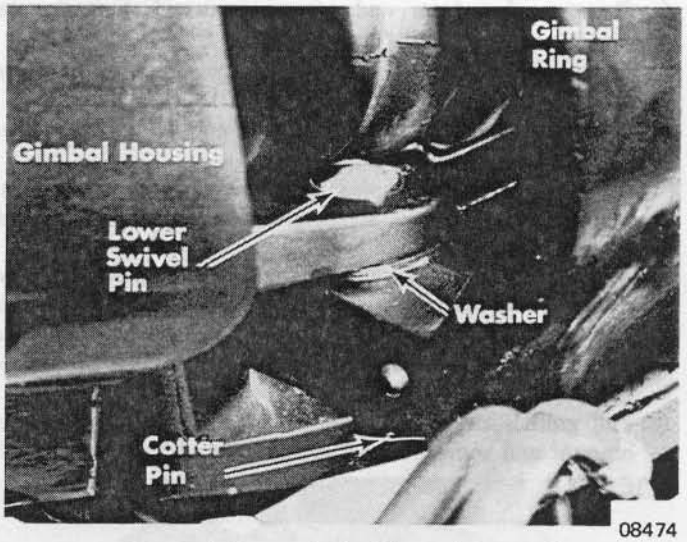


Figure 4. Lower Swivel Pin and Cotter Pin

5. Remove 2 screws and stop switch actuating lever. (Figure 5)

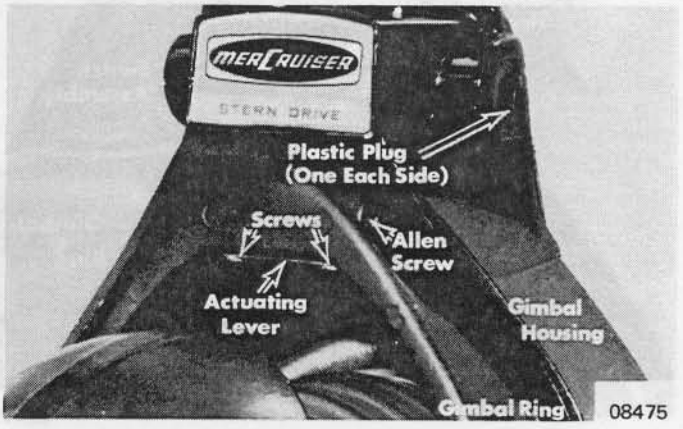


Figure 5. Actuator Lever, Allen Screws and Plastic Plugs

Figure 6. Steering Lever and Brass Pipe Plug

6. Remove plug from end of upper swivel shaft (located under switch actuating lever). (Figure 5)
7. Remove upper swivel shaft allen screw and washer from side of gimbal ring. (Figure 5)
8. Remove 2 plastic plugs from upper end of gimbal housing (one each side). (Figure 5)
9. Insert wrenches thru holes (from which plastic plugs were removed) and remove steering lever to upper swivel shaft screw. (Figure 6)
10. Remove brass pipe plug from top of gimbal housing. Drive upper swivel shaft down (using a punch thru pipe plug hole) a sufficient amount to disengage shaft from gimbal housing. (DO NOT drive shaft all-the-way out, or bellows may be damaged.)
11. Pull gimbal ring away from gimbal housing a sufficient amount and remove 2 screws and nuts which secure switch in gimbal ring. (Figure 7) (Run Power Trim down to aid in positioning gimbal ring.)
12. Remove 2 screws, which hold switch harness to gimbal housing, and remove switch assembly. (Figure 7)

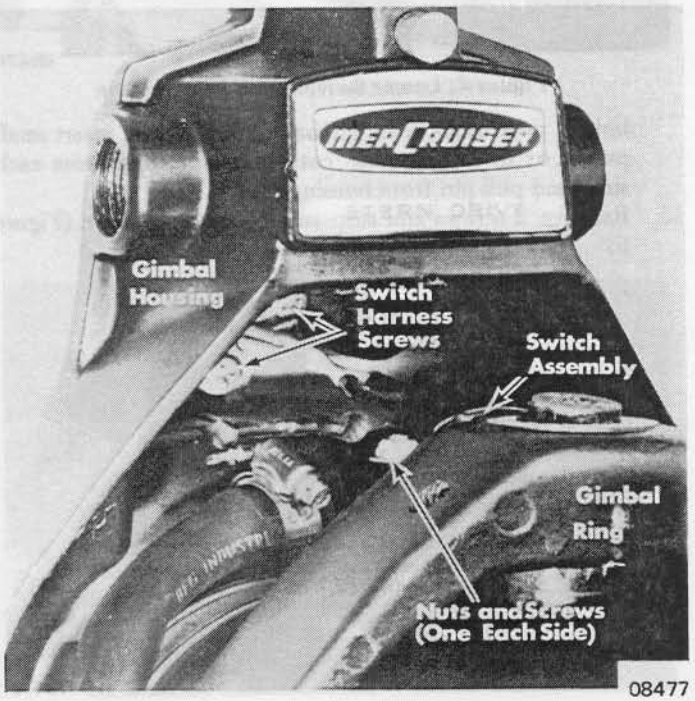


Figure 7. Tilt Stop Switch

INSTALLATION

1. Install new switch in gimbal ring. Switch leads must be positioned as shown in Figure 8, or leads may become shorted to gimbal ring.
2. Insert switch harness thru gimbal housing and install 2 screws which hold switch harness to gimbal housing. (Figure 7)
3. Place gimbal ring in position in gimbal housing.
4. Place shim and steering lever in position (straight forward) and install upper swivel shaft thru steering lever. (If difficulty is encountered when installing shaft, install lower swivel pin to align gimbal ring.)
5. Adjust height of swivel shaft to allow installation of allen screw thru side of gimbal ring. Torque screw to 20 ft. lbs. (2.77mkg). (Figure 5)

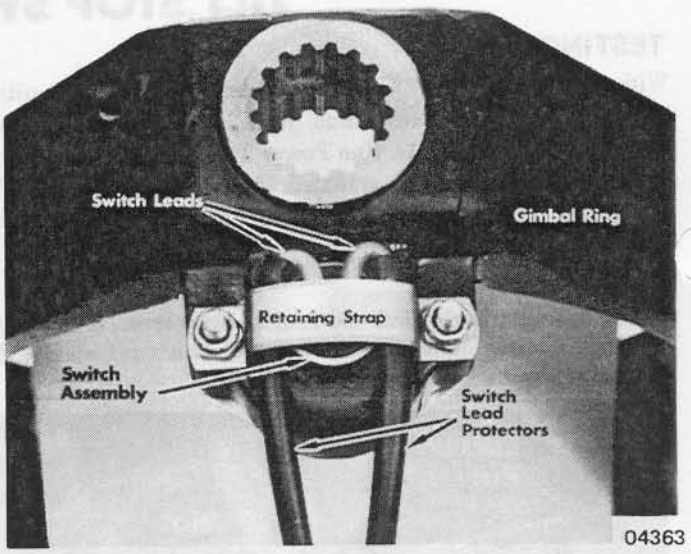


Figure 8. Switch Leads Installed

6. Install bolt thru steering arm and torque to 45 ft. lbs. (6.22mkg). (Figure 6)
7. Apply sealer to threads and install plastic plugs (one on each side of gimbal housing). (Figure 5)
8. Install plug in end of upper swivel shaft.
9. Install brass pipe plug in top of gimbal housing.
10. Install switch actuating lever. (Figure 5)
11. Install lower swivel pin, washer and cotter pin. (Figure 4)
12. Check clearance between gimbal ring and gimbal housing at lower swivel pin (.015" to .030" [.38mm to .76mm]). Adjust clearance (if necessary) by adding or removing washers from under steering lever.
13. Run Power Trim in "down" direction until hinge pins can be installed.
14. Install washers, hinge pins and hinge pin retaining pin.
15. Connect steering link rod to steering lever.
    a. On steering link rod with castle nut, torque nut to 20-25 in. lbs. (23-28.8kg-cm) and, if necessary, back nut off slightly to install cotter pin. (Figure 3)
    b. On steering link rod with nylock nut, torque nut to 50-60 in. lbs. (58-69kg-cm).

EXHAUST ELBOW and SHUTTER REPLACEMENT

REMOVAL

1. After removing drive unit and engine, remove screws and lockwashers from gimbal housing to remove exhaust elbow and "O" ring(s). (Figures 9 and 10)

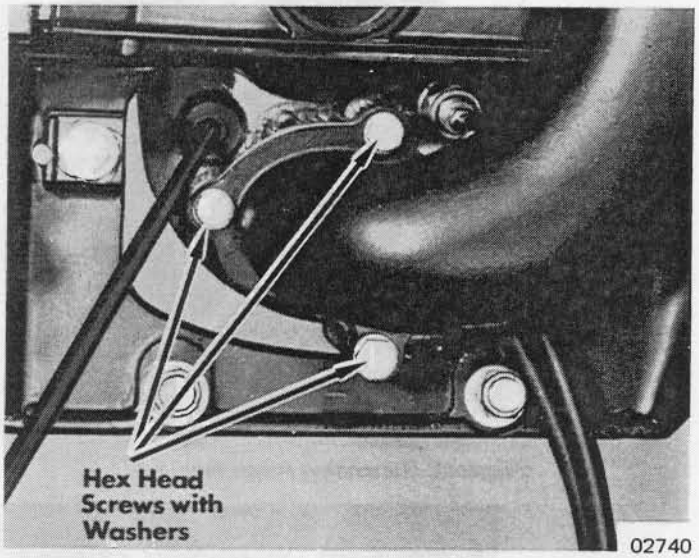


Figure 9. Exhaust Elbow and "O" Ring in Groove for In-Line Engine

2. Remove exhaust bellows and remove holding support bracket for water shutter, if replacement is necessary.

NOTE: On "V-8" engines, water shutters are located in exhaust separator.

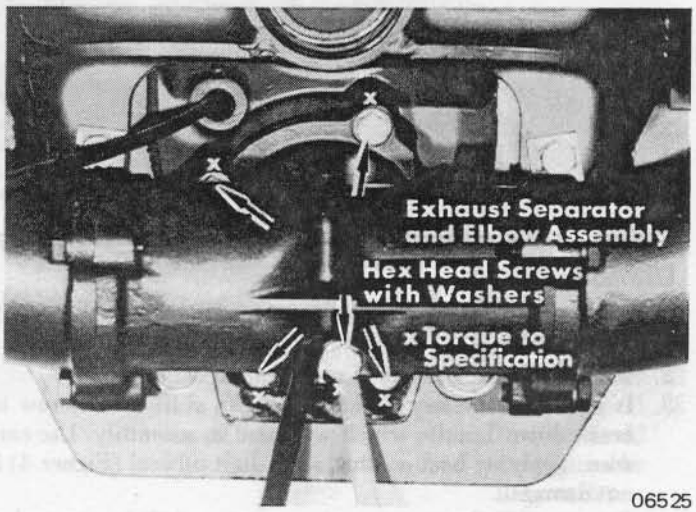


Figure 10. Exhaust Separator and Elbows for V-8 Engines

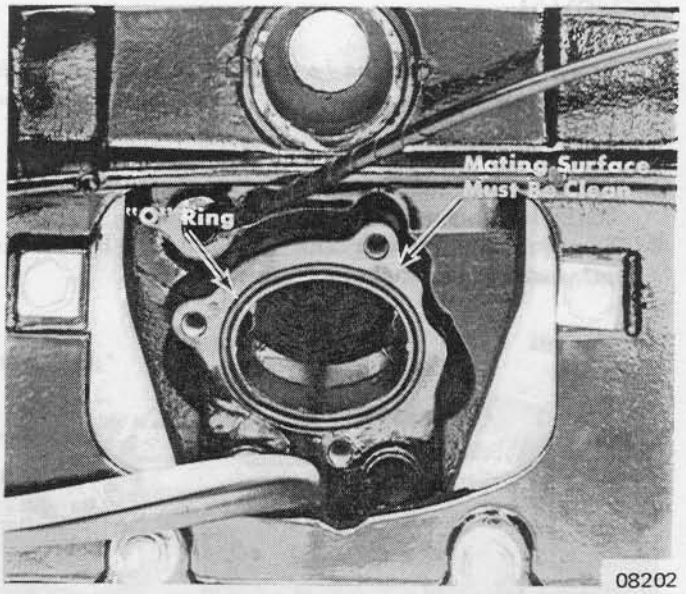


Figure 11. Positioning "O" Ring in Groove on In-Line Engines

INSTALLATION

1. Clean mating surfaces on elbow and gimbal housing.
2. Place "O" ring in groove of gimbal housing. (Figures 11 and 12)
3. Reinstall elbow with screws and lockwashers, torquing them to specification. Be certain that "O" ring remains seated in groove, properly sealing joint to prevent leakage.

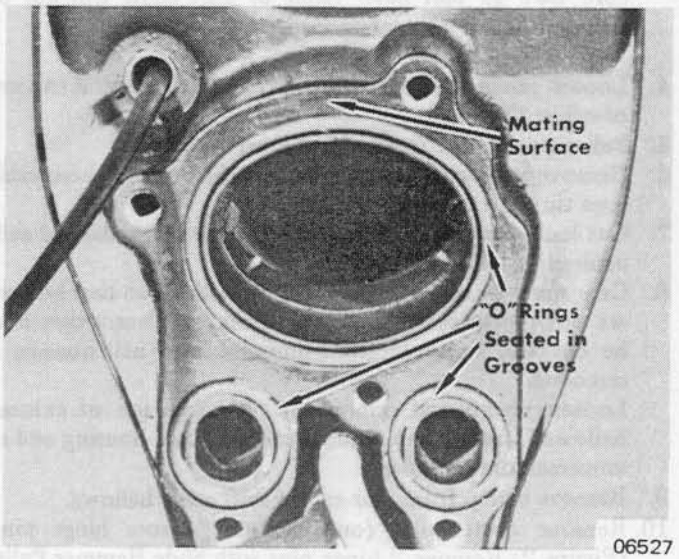


Figure 12. "O" Ring Locations for V-8 Engines

GIMBAL HOUSING DISASSEMBLY

REMOVAL from BOAT

Remove gimbal housing and transom plate from boat by referring to "Removal-Installation-Alignment" Section 2.

BELL HOUSING

REMOVAL

NOTE: Bell housing can be removed with gimbal housing installed on Repair Stand (C-91-33750) or installed on boat.

1. Remove drive unit from bell housing by referring to "Removal-Installation-Alignment" Section 2.
2. Remove drive unit shift cable from shift plate by removing nut, washer and cotter pin. (Figure 1)

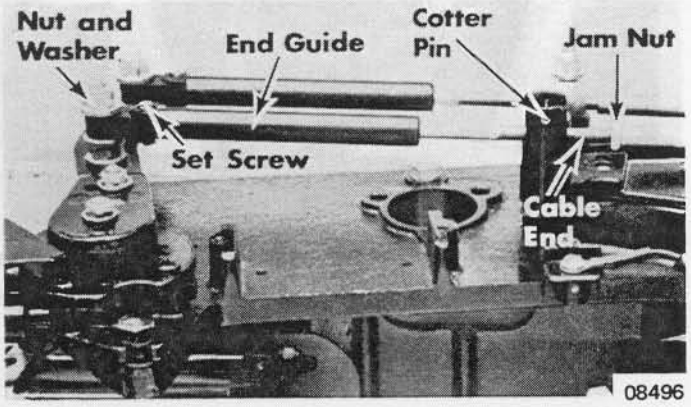


Figure 1. Drive Unit Shift Cable

3. Remove set screws from cable end guide and remove end guide. (Figure 1)

   NOTE: Burrs, made by set screws, must be removed from core wire so that inner lining of shift cable will not be damaged when wire is removed.

4. Loosen jam nut on metal cable end and turn metal end out of cable. (Figure 1)
5. Pull support tube from end of inner core wire.
6. Remove protective wrapping from shift cable where cable goes through transom.
7. Cut lock wire and remove allen set screw from end of shift cable slide. (Figure 2)
8. Care must be taken when removing bellows so that bellows are not punctured. If bellows are being replaced, they may be cut and removed from housings after bell housing is removed.

   Loosen clamp and remove bell housing end of exhaust bellows. Loosen clamp and remove gimbal housing end of universal joint bellows.
9. Remove clamp from rear end of shift cable bellows.
10. Remove cotter pins (one each side) from hinge pins. (Figure 2) Remove 2 hinge pins with Slide Hammer Puller (C-91-34569A1) and Hinge Pin Puller (C-91-36060).
11. Loosen clamp and remove water hose from tube located in gimbal housing.
12. Remove exhaust bellows from gimbal housing with screwdriver through hole provided inside of gimbal housing. (Figure 3)

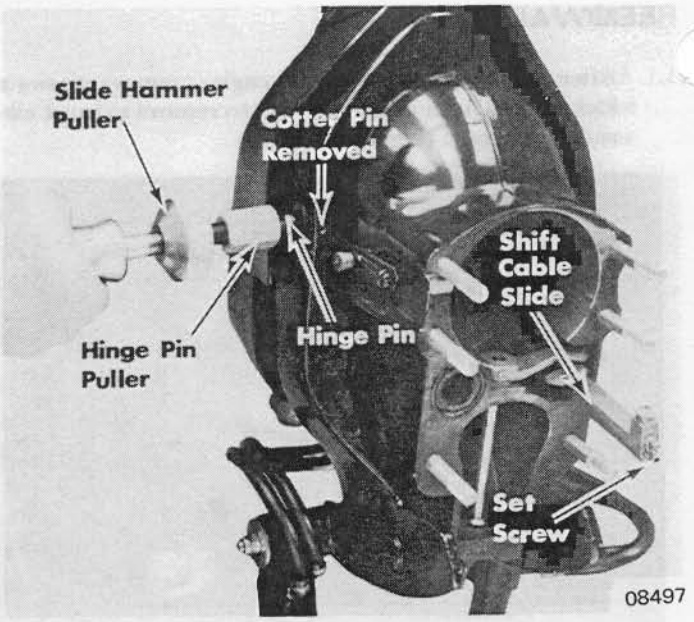


Figure 2. Removing Hinge Pins

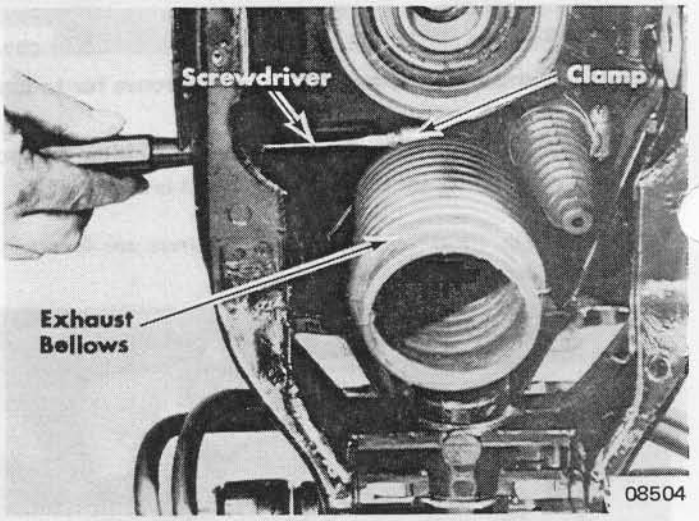
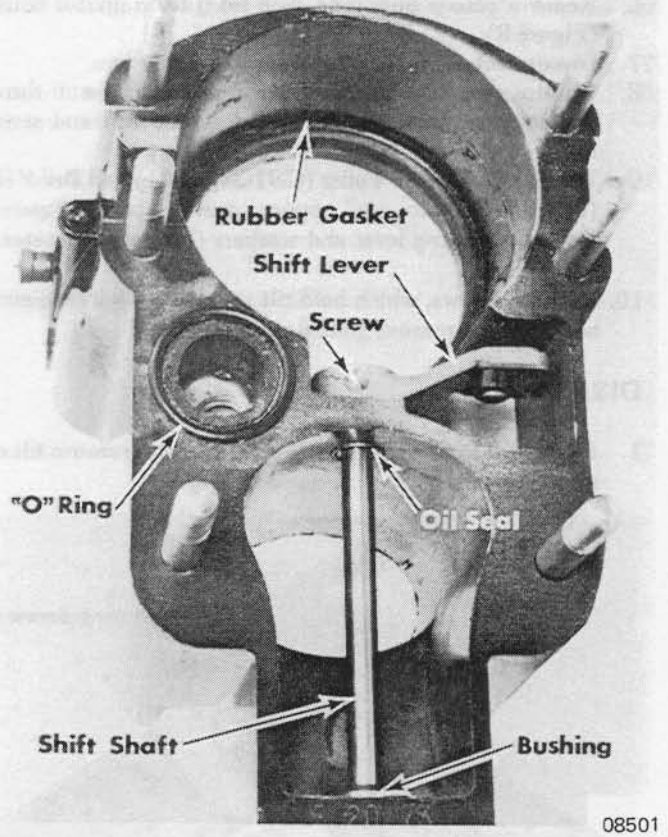


Figure 3. Removing Exhaust Bellows from Gimbal Housing

DISASSEMBLY

1. Remove universal joint bellows, water hose and shift cable from bell housing.
2. Remove rubber bumper if replacement is necessary.
3. It may be necessary to apply heat to shift lever screw to break down Loctite which was used in assembly. Use care when applying heat so that shift shaft oil seal (Figure 4) is not damaged.

   Remove shift lever screw, then remove shift lever, washer and shift shaft. (Figure 4)
4. Remove shift shaft oil seal and bushing (Figure 4), if replacement is necessary.
5. Remove "O" ring (located around water passage) (Figure 4) and rubber gasket (located in universal joint passage). (Figure 4)



CLEANING and INSPECTION

1. Clean all metal parts in solvent and dry with compressed air.
2. If bellows are to be re-used, remove bellows adhesive from inside diameter of bellows with lacquer thinner.
3. Inspect bellows carefully for cracks, cuts, punctures and flexibility. If bellows serviceability is doubtful, replace bellows.
4. Clean bellows mounting flanges of bell housing with wire brush or sandpaper, then wipe with lacquer thinner.
5. Check shift cable for cuts or damage caused by cable which is pinched or bent too short.
6. Inspect water hose for cracks, cuts, punctures, worn spots from rubbing and flexibility.
7. Inspect shift shaft oil seal for tears, wear or roughness.
8. Check shift shaft and shift shaft bushings for wear.
9. Check "O" ring and rubber gasket for cuts, nicks, hardness and cracks.
10. If shift lever roller is worn, replace shift lever assembly.
11. Check rubber bumper for damage.
12. If heat was used to remove shift lever screw, check washer under lever for damage.

Figure 4. Shift Shaft Removal

GIMBAL RING

REMOVAL

NOTE: Gimbal ring can be removed with gimbal housing installed on Repair Stand (C-91-33750) or installed on boat.

1. Remove 2 nuts from hydraulic hose connector. (Figure 5) Lower the connector. Remove and cap 2 hydraulic hoses from top of connector. Plug hose connections in connector to prevent losing oil and keep dirt out of hydraulic system.
2. Remove trim cylinder forward anchor pin (Figure 5) and place assembly to the side.

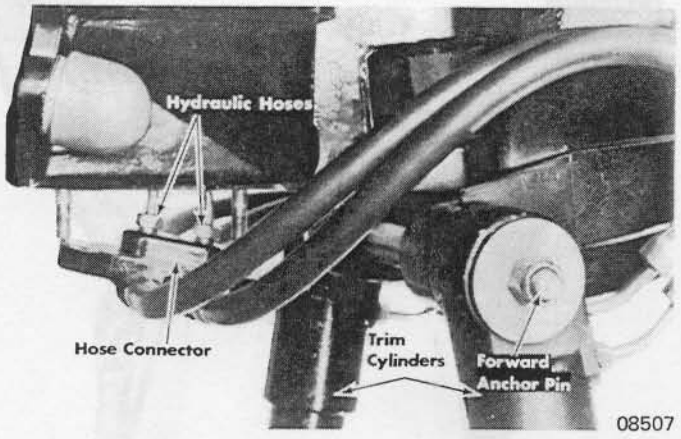


Figure 5. Removing Trim Cylinders

3. Remove cotter pin, lower swivel pin and washer. (Figure 6)
4. Remove 2 screws and remove tilt stop switch actuating lever. (Figure 7)

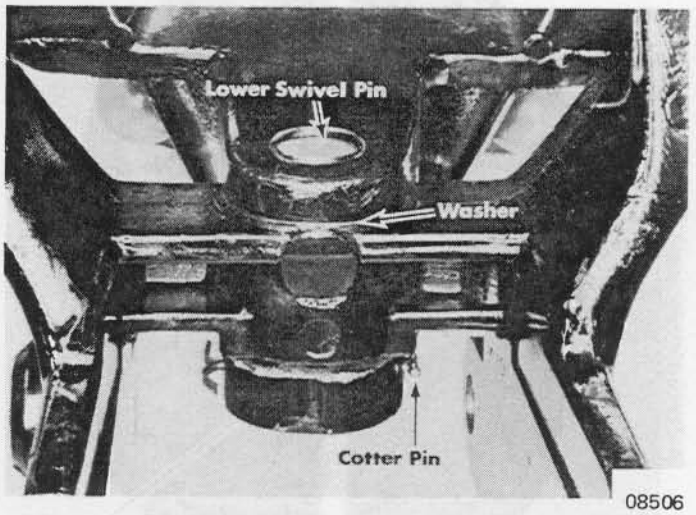


Figure 6. Removing Lower Swivel Pin

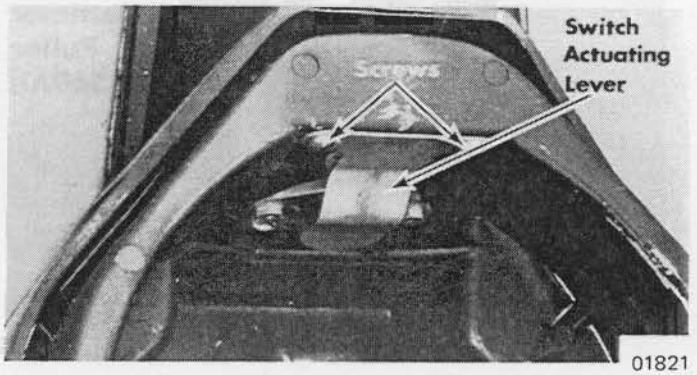


Figure 7. Tilt Stop Switch Actuating Lever

5. Remove allen screw from bottom of upper swivel shaft and from top side of gimbal ring. (Figure 8)

Figure 8. Preparing for Upper Swivel Shaft Removal

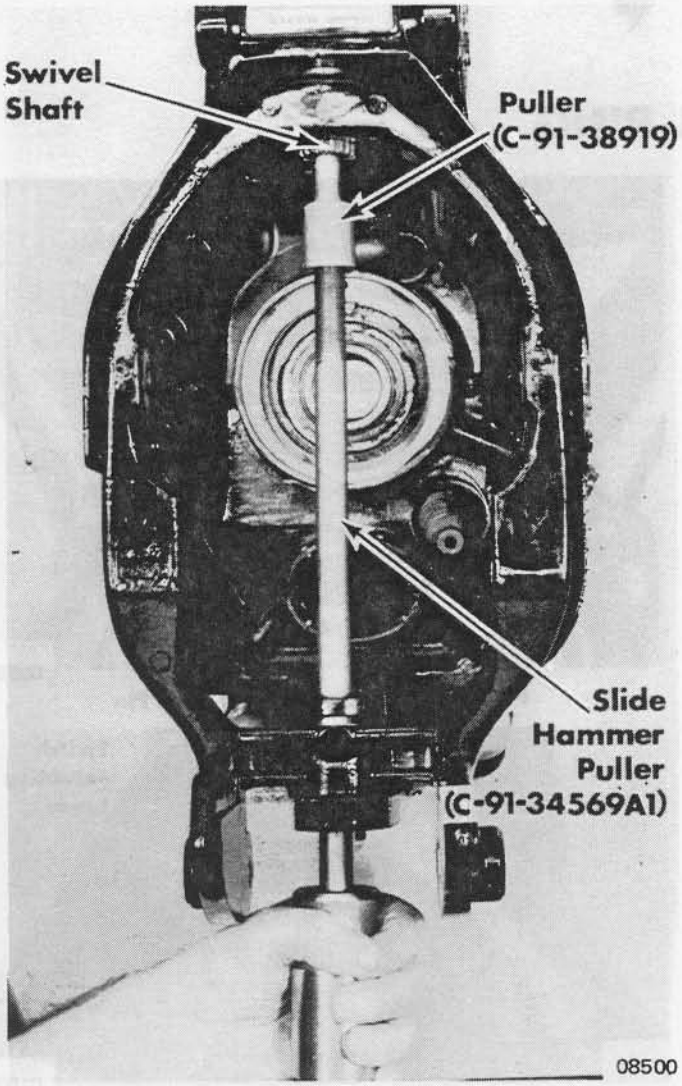


Figure 9. Removing Upper Swivel Shaft

6. Remove plastic plug (one each side) from gimbal housing. (Figure 8)
7. Disconnect steering link rod from steering arm.
8. Obtain access to steering lever screw and nut through plastic plug holes, then remove screw, nut and steering lever.
9. Use Slide Hammer Puller (C-91-34569A1) and Puller Head (C-91-38919) to pull upper swivel shaft. (Figure 9) Remove steering lever and washers (located under steering lever).
10. Remove screws, which hold tilt stop switch wires to gimbal housing, and remove gimbal ring assembly.

DISASSEMBLY

1. Remove 2 screws and nuts (Figure 10) and remove tilt stop switch assembly.

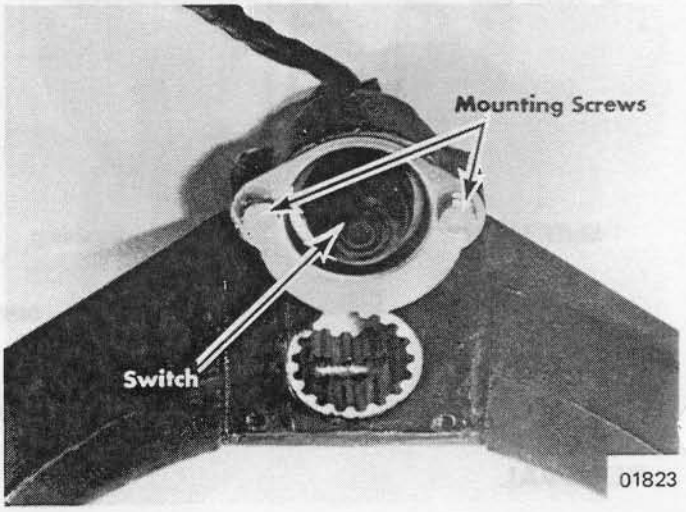


Figure 10. Tilt Stop Switch Assembly

2. Drive or press lower swivel pin roller bearing and 2 oil seals out of gimbal ring with Driver (C-91-33492). (Figure 11)

NOTE: Oil seals may be pried out of gimbal ring without removing bearing, if bearing replacement is not necessary.

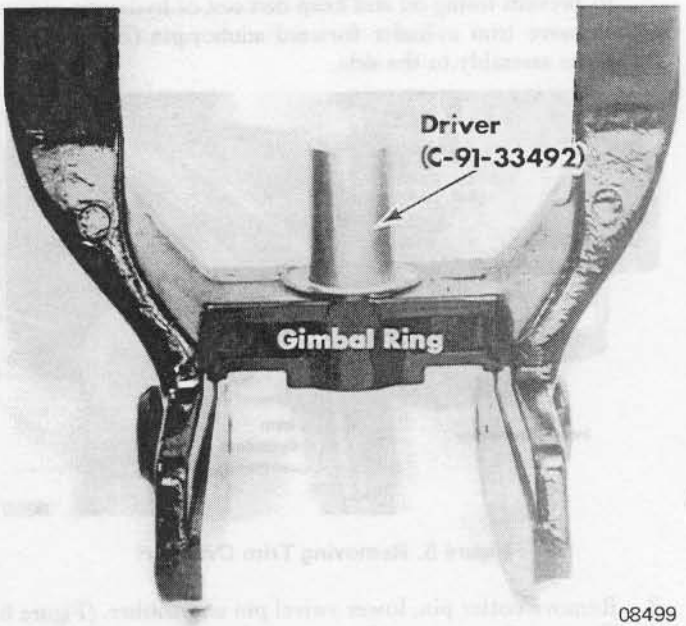


Figure 11. Lower Swivel Pin Needle Bearing Removal

CLEANING and INSPECTION

1. Clean gimbal ring and bearing in solvent and dry with compressed air.
2. Check surface of lower swivel pin in area where needle bearing rides. Pitting, grooves and uneven wear are causes for bearing and swivel pin replacement.
3. Inspect oil seals for wear, tears and roughness on lip surface.

TILT STOP SWITCH TESTING

NOTE: Switch need not be removed to be tested. Use Power Trim tilting action of drive unit to actuate switch button.

1. Connect continuity meter or test lamp to switch leads. Meter should show continuity, or lamp lights.
2. Actuate switch button. Meter should show NO continuity, or lamp should NOT light.

GIMBAL HOUSING

REMOVAL

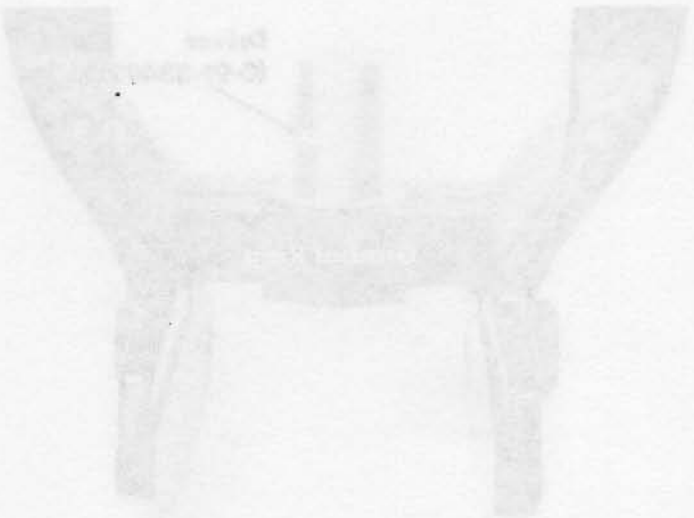
To remove gimbal housing from transom, refer to "Removal-Installation-Alignment" Section 2.

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air.
2. Check gimbal housing ball bearing by rotating inside race of bearing and by checking for rough spots. Check bearing for side wear. Pull and push on inner race. Any excessive movement is cause for replacement.
3. To check upper swivel shaft roller bearing and bushing, inspect area of swivel shaft where bearing and bushing ride. Pitting, grooves and uneven wear are causes for bearing, bushing and swivel shaft replacement.

DISASSEMBLY

1. To remove gimbal housing ball bearing, refer to "Gimbal Housing Ball Bearing Removal" (see "Index").
2. Remove brass pipe plug from top of gimbal housing. Use a punch and hammer (thru plug hole) to remove upper swivel shaft roller bearing, bushing and oil seals.
3. Remove 2 screws from water tube cover and remove cover, rubber bushing and water tube.



GIMBAL HOUSING REASSEMBLY

GIMBAL HOUSING

REASSEMBLY

1. Drive bushing and oil seal into gimbal housing with Bushing Driver (C-91-33489). (Figure 1) Oil seal lip faces up.
2. Install roller bearing and oil seals with Bearing Driver (C-91-33491). Oil seal lip faces up. (Figure 1)
3. Install brass pipe plug into gimbal housing.
4. Install water tube thru hole in gimbal housing. Place rubber bushing over tube and install cover.
5. For gimbal housing ball bearing installation, refer to "Gimbal Housing Ball Bearing Installation" (see "Index").

INSTALLATION

For gimbal housing installation, refer to "Removal-Installation-Alignment" Section 2.

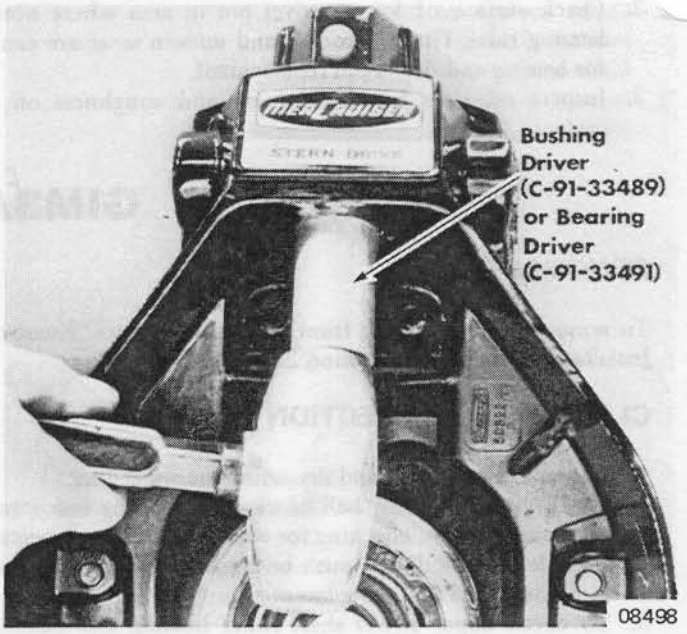


Figure 1. Needle Bearing, Bushing and Oil Seal Installation

GIMBAL RING

REASSEMBLY

1. Install lower swivel pin roller bearing and oil seals with Bearing Driver (C-91-33492). (Figure 2)

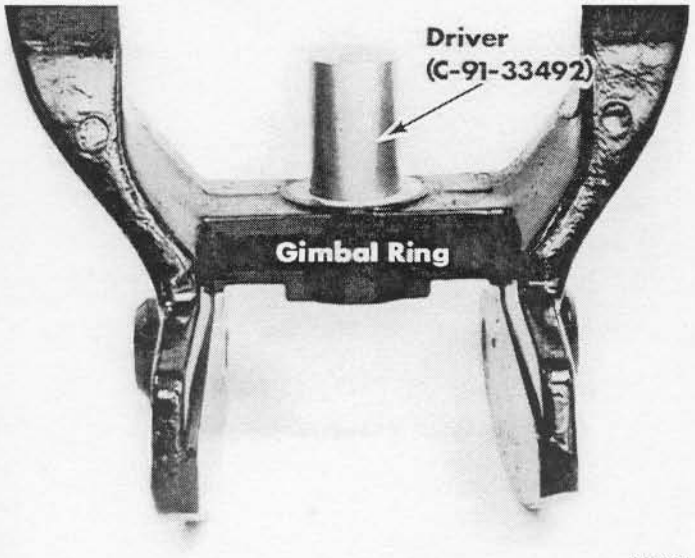


Figure 2. Installing Swivel Pin Needle Bearing and Oil Seals

2. When installing tilt stop switch, switch leads must be positioned as shown in Figure 3.

INSTALLATION

1. Insert switch harness thru gimbal housing and install 2 screws which hold switch harness to gimbal housing.
2. Place gimbal ring in position in gimbal housing.

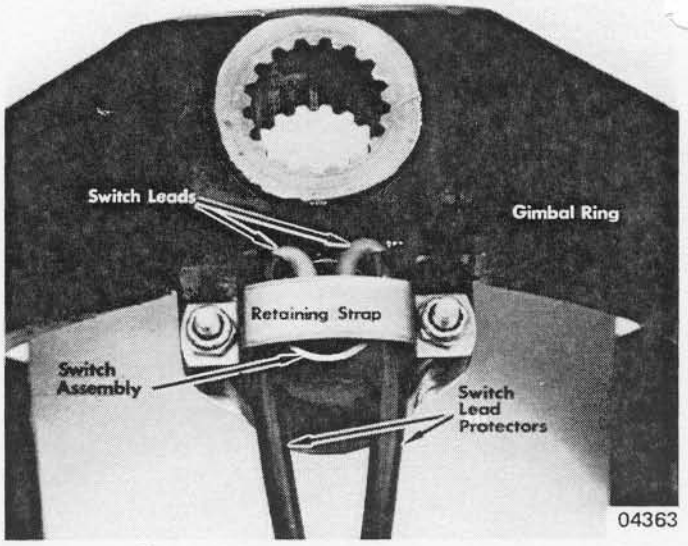


Figure 3. Tilt Stop Switch Installation

3. Place washer between gimbal ring and gimbal housing and install lower swivel pin and cotter pin. (Figure 4)
4. Place shim washers and steering lever in position (straight forward) and install upper swivel shaft thru gimbal ring, gimbal housing and steering lever.
5. Adjust height of swivel shaft to allow installation of allen screw thru side of gimbal ring. Torque screw to specifications. (Figure 5)
6. Install bolt thru steering arm and torque to specifications.
7. Check clearance between gimbal ring and gimbal housing. (Figure 6) Clearance must be between .005" to .030" (.13mm to .76mm). Add or remove shim washers under steering lever to correct clearance.

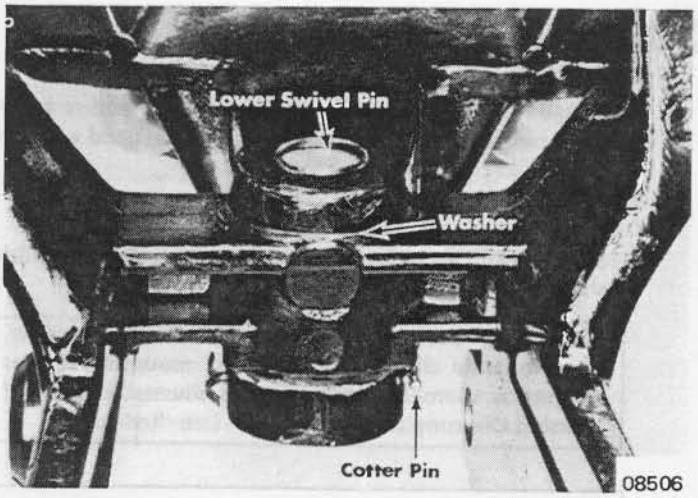


Figure 4. Lower Swivel Pin Installation

Figure 5. Upper Swivel Shaft Installation

8. Apply Perfect Seal (C-92-34227) to threads and install plastic plug (one each side of gimbal housing). (Figure 5)
9. Apply Perfect Seal to threads and install allen screw in end of upper swivel shaft. (Figure 5)
10. Install switch actuating lever. (Figure 7)
11. Install trim cylinders with cylinder anchor pin. (Figure 8)
12. Install 2 hydraulic hoses to connector and install connector to gimbal housing (Figure 8) with 2 internal lockwashers and 2 nuts (not shown).
13. Connect steering link rod to steering lever. Torque nut to specification and, if necessary, back nut off slightly to install cotter pin.

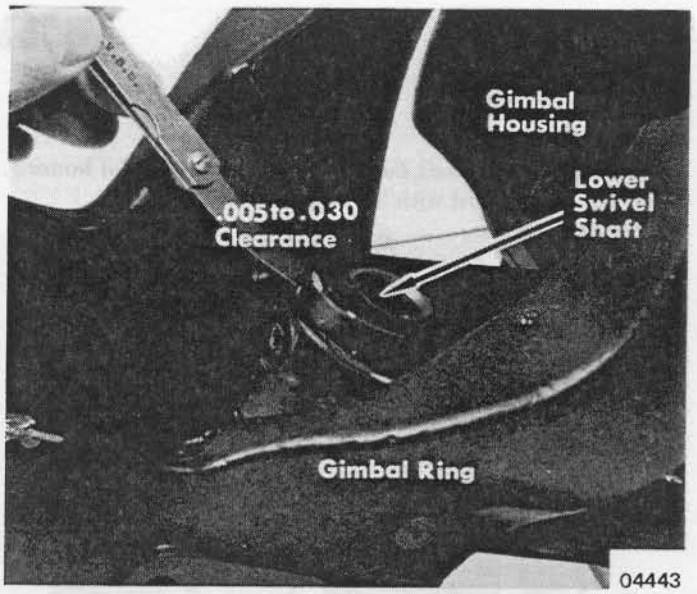


Figure 6. Clearance between Gimbal Housing and Ring

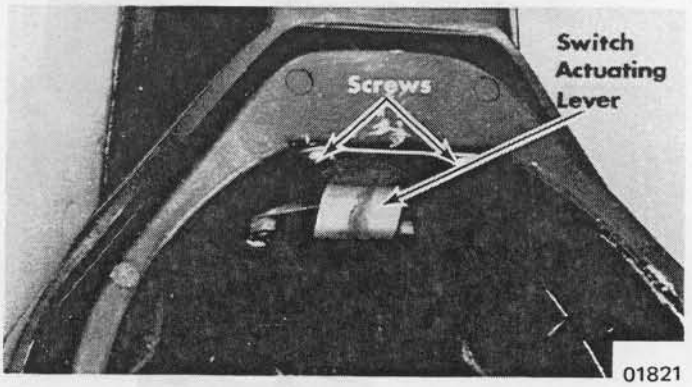


Figure 7. Switch Actuating Lever Installation

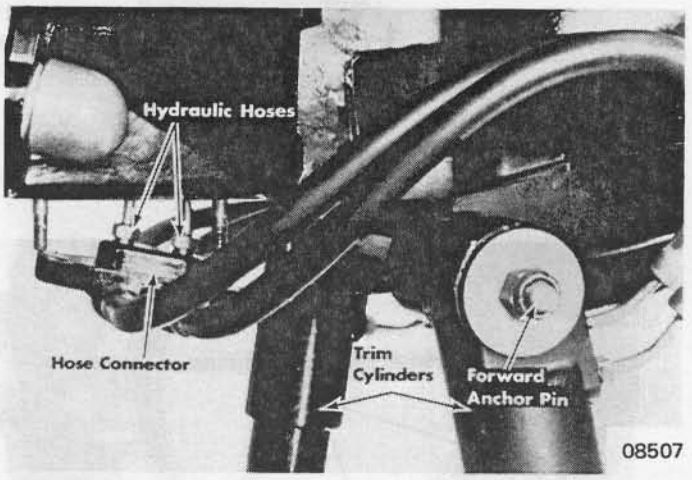


Figure 8. Hydraulic Cylinder and Hose Installation

REASSEMBLY

1. Install shift shaft bushing flush with bottom of housing.
2. Install oil seal with lip facing down. (Figure 9)

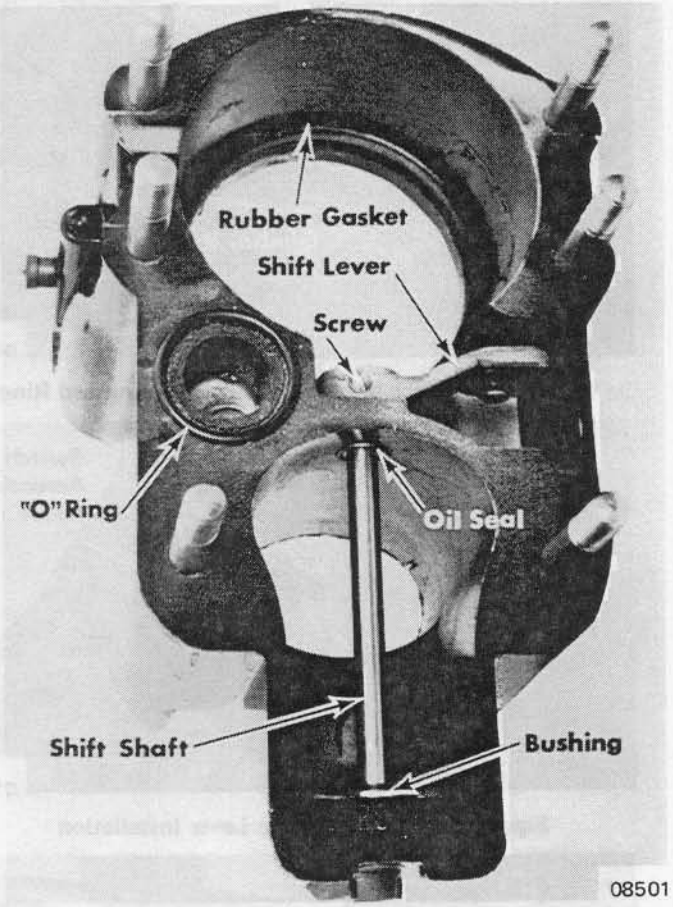


Figure 9. Shift Shaft Installation

3. Install shift shaft, washer and shift lever.
4. Apply a drop of Loctite "A" (C-92-32609) on threads of locking screw. Install screw thru shift shaft and into shaft lever. (Figure 9)

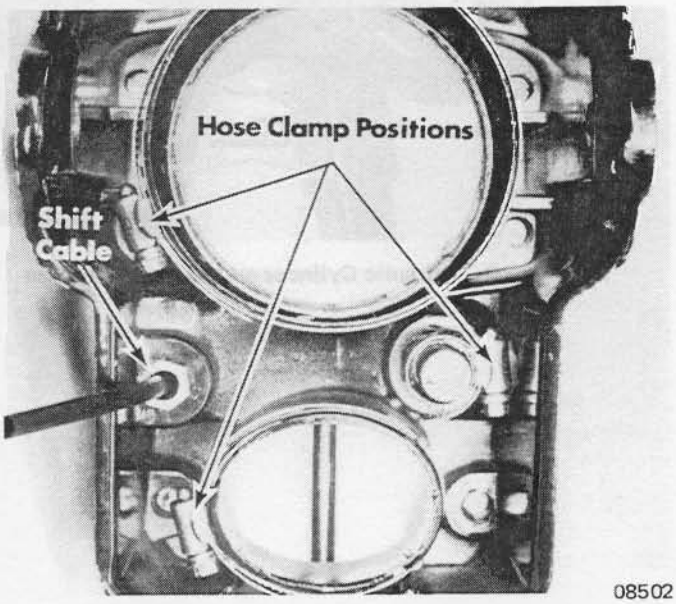


Figure 10. Approximate Hose Clamp Position on Bell Housing

5. Install "O" ring around water passage and rubber gasket in universal joint passage. (Figure 9) Use a general adhesive hold gasket and "O" ring in place.
6. Install rubber bumper (if removed).
7. Install shift cable. (Figure 10)
8. Install water hose to bell housing with clamp position, as shown in Figure 10.

CAUTION: Before installing universal joint bellows, clean outside diameter of bellows mounting flanges and inside diameter of bellows as illustrated in "Bell Housing Cleaning and Inspection" (see "Index").

WARNING: Extremely Flammable! Vapors from Bellows Adhesive may cause flash fire or ignite explosively. Prevent buildup of vapors. Open all windows and doors. Use only in cross-ventilation. Keep away from heat, sparks and open flame. DO NOT SMOKE. Extinguish all flames and pilot lights and turn off stoves, heaters, electric motors and all other sources of ignition during use and until all vapors are gone. Close container after each use. Contains TOLUOL and petroleum distillates. Harmful or fatal if swallowed. Avoid prolonged contact with skin or breathing of vapors. If swallowed, do not induce vomiting. Call physician immediately. Keep out-of-reach of children.

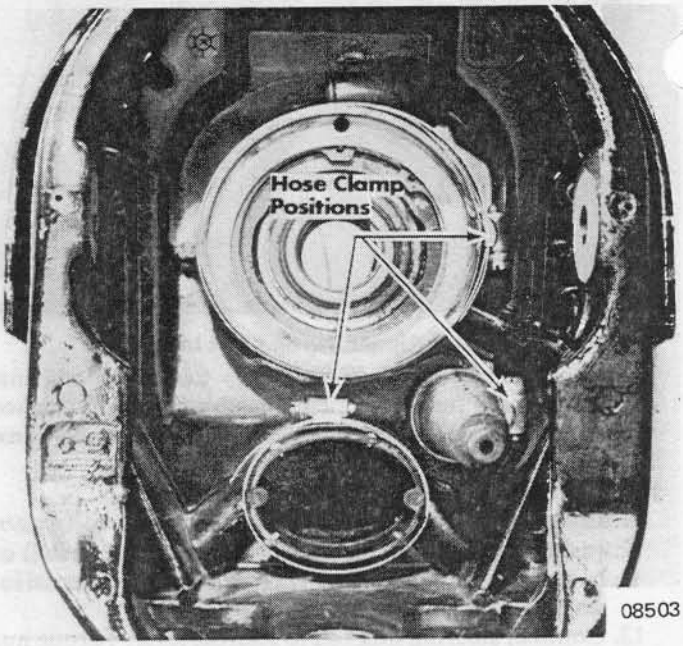


Figure 11. Approximate Hose Clamp Position on Gimbal Housing

9. Apply Bellows Adhesive (C-92-36340A1) to inside diameter of each end of universal joint bellows. Allow adhesive to dry approximately 10 minutes, or until no longer tacky.
10. Install end of universal joint bellows marked "Aft-Top" t bell housing. Position clamp as shown in Figure 10 an torque clamp to specification.
11. Install exhaust bellows and shift bellows to gimbal housing with clamp positioned as shown in Figure 11. Torque clamp to specification.

INSTALLATION

1. Insert shift cable thru shift cable bellows.
2. Install water hose to tube.
3. Place hose clamps on universal joint and exhaust bellows.
4. Install universal joint bellows over gimbal housing mounting flange. DO NOT tighten clamp at this time.
5. Align washer and hinge pin holes (located in bell housing and gimbal ring; one each side). Use Multipurpose Lubricant (C-92-63250) on washer to hold washer in position during installation. Install hinge pin.
6. Install hinge pin retainer pin and bend retainer pin over in slot provided on front of gimbal ring.
7. Check position of universal joint bellows on gimbal housing mounting flange, to be sure of proper installation, and torque clamp to specification.
8. Install exhaust bellows on bell housing with Expander Tool (C-91-45497A1). (Figure 12) Torque hose clamp to specification.

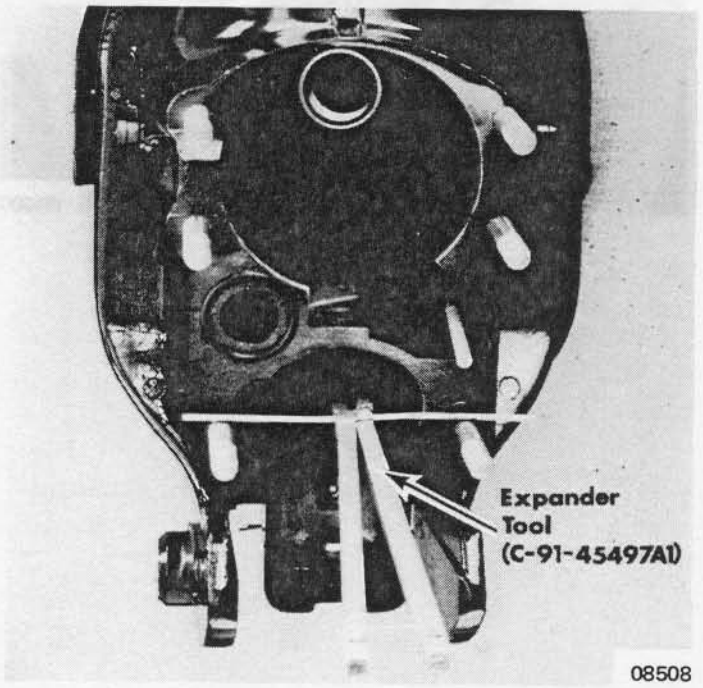


Figure 12. Installing Exhaust Bellows to Bell Housing

9. Install clamp on rear end of shift cable bellows. End of bellows must be approximately 2" (51mm) from cable connector (located in bell housing). Squeeze clamp securely to prevent water from entering bellows.
10. Turn cable end into shift cable (Figure 13) until it bottoms out, then tighten jam nut.

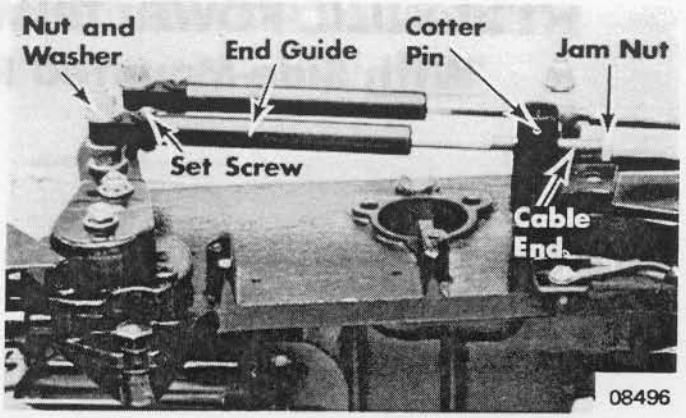


Figure 13. Installing Shift Cable

11. Install cable slide and inner core wire. (Figure 14)
12. Install and tighten allen set screw securely, then back off approximately ¼-turn. The screw must be loose enough to permit core wire to turn or rotate freely, but tight enough to minimize end play between cable and cable slide. Secure screw with lockwire.
13. Install support tube on end of inner core wire approximately ½" (12.7mm) from end of wire. Crimp support tube to secure its position on core wire.
14. Install end guide on cable and tighten set screws securely. (Figure 13)
15. Shift cable assembly is installed as shown in Figure 13.
16. Place protective wrapping on shift cable in area where cable extends thru transom.
17. Install drive unit and adjust shift cables. Refer to "Removal-Installation-Alignment" Section 2.

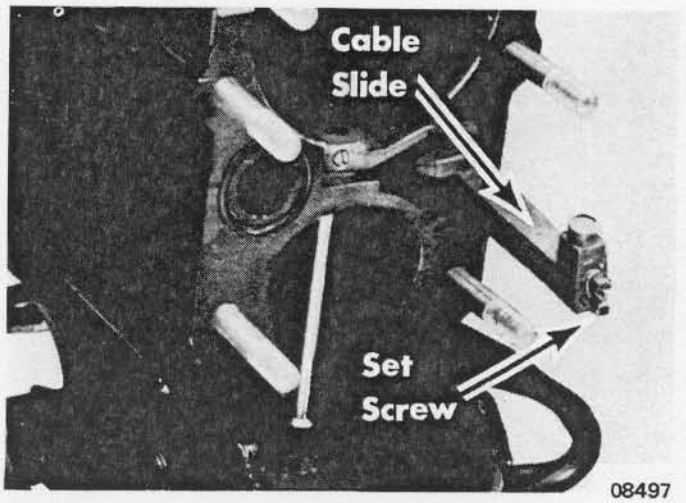


Figure 14. Cable Slide Installation

HYDRAULIC POWER TRIM TRANSOM PLATE ASSEMBLY
With Side-Mounted Rotary Switch (Figure 1)

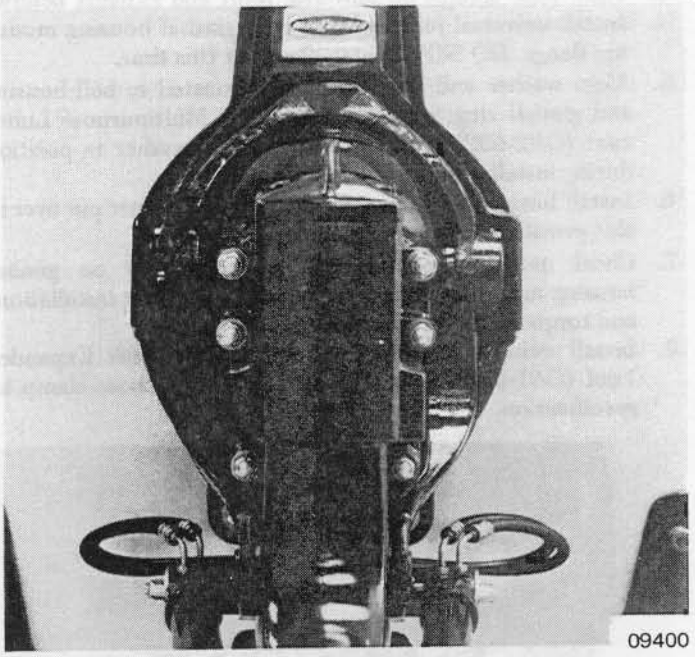


Figure 1. Transom Plate and Drive with Side Mounted Rotary Switch

GIMBAL HOUSING BALL BEARING

INSPECTION

1. Remove drive unit from bell housing, as outlined in "Removal" Section 2.
2. Reach thru bell housing and rotate bearing to check for rough spots. Pull and push on inner race to check for side wear. Any excessive movement is cause for replacement.

REMOVAL

CAUTION: Gimbal bearing may be damaged during removal. Do not remove bearing cartridge assembly unless replacement is necessary.
Replacement bearings come as an assembly with cartridge and must be replaced as an assembly.

1. Remove drive unit from bell housing as outlined in "Removal" Section 2.
2. Remove bearing cartridge assembly with tools illustrated in Figure 2. Two (2) plates (C-91-29310) must be used. Position plates between top and middle studs (located on bell housing). Use 3-jaw puller from Slide Hammer Puller (C-91-34569A1).
   If bearing assembly is very tight, it may be necessary to tap end of Puller Shaft (C-91-31229) with a mallet while turning nut (C-11-24156).

NOTE: Older Bearing Removal and Installing Kits (C-91-31229A4) will need 5/8-18 threads cut in unthreaded portion of Puller Shaft (C-91-31229) to accept slide hammer 3-jaw puller and jaw spreader adaptor.

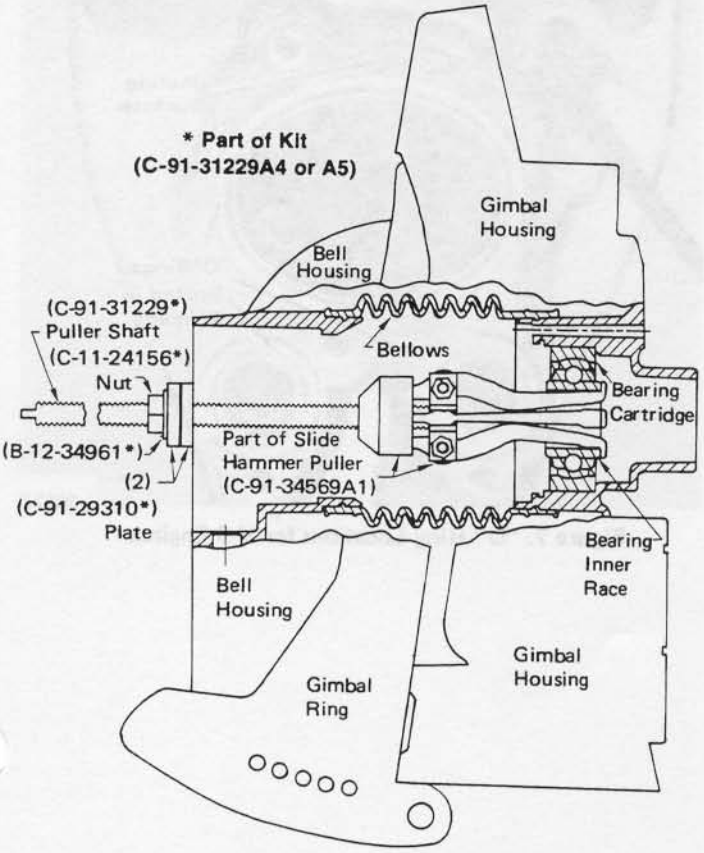


Figure 2. Removing Bearing Cartridge Assembly

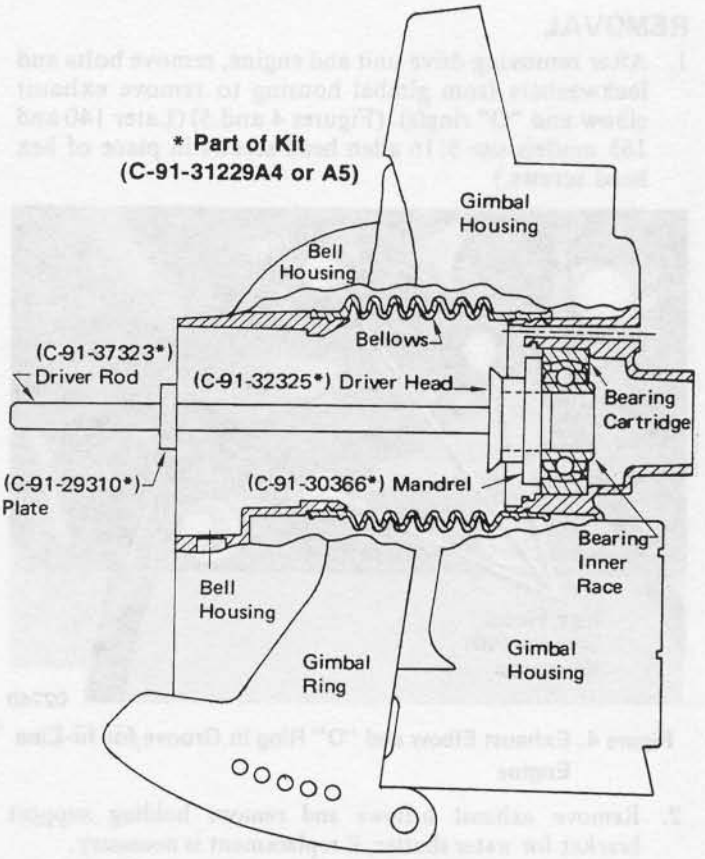


Figure 3. Installing Bearing Cartridge Assembly

INSTALLATION

1. Lubricate outside of cartridge gimbal bearing assembly with Quicksilver Multipurpose Lubricant (C-92-63250).
2. Install bearing cartridge assembly with tools illustrated in Figure 3.
3. Insert Driver Head (C-91-32325) thru Mandrel (C-91-30366) and into inside diameter of bearing assembly.
4. Align bearing cartridge assembly with gimbal housing cavity. Place Plate (C-91-29310) between top and middle studs (on bell housing) as a pilot. Drive bearing cartridge assembly into gimbal housing cavity with a lead hammer or mallet.
5. Lubricate cartridge gimbal bearing with Pistoluber (C-91-37299), using ONLY Quicksilver Multipurpose Lubricant thru grease fitting. Pump 40 full strokes (1 oz.) to adequately lubricate bearing.

NOTE: Use Engine Alignment Shaft (C-91-48247 or C-91-57797A3) to align gimbal bearing after installation and check engine alignment.

6. Install drive unit as outlined in "Installation" Section 2.

EXHAUST ELBOW and SHUTTER REPLACEMENT

REMOVAL

1. After removing drive unit and engine, remove bolts and lockwashers from gimbal housing to remove exhaust elbow and "O" ring(s). (Figures 4 and 5) (Later 140 and 165 models use 5/16 allen head screws in place of hex head screws.)

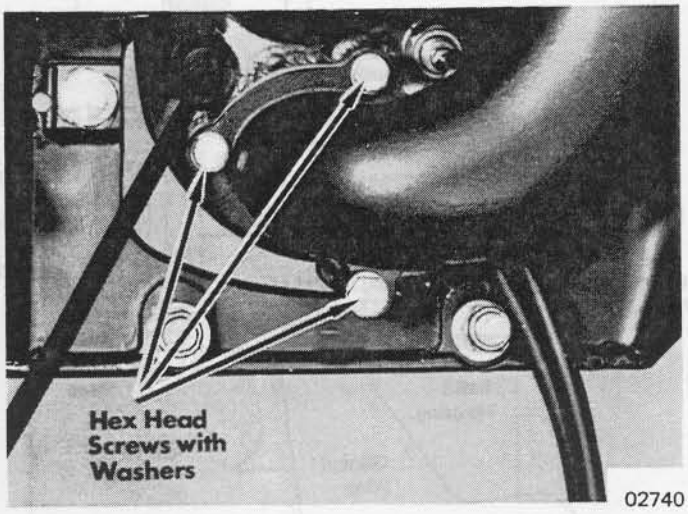


Figure 4. Exhaust Elbow and "O" Ring in Groove for In-Line Engine

2. Remove exhaust bellows and remove holding support bracket for water shutter, if replacement is necessary.

NOTE: On "V-8" engines, water shutters are located in exhaust separator.

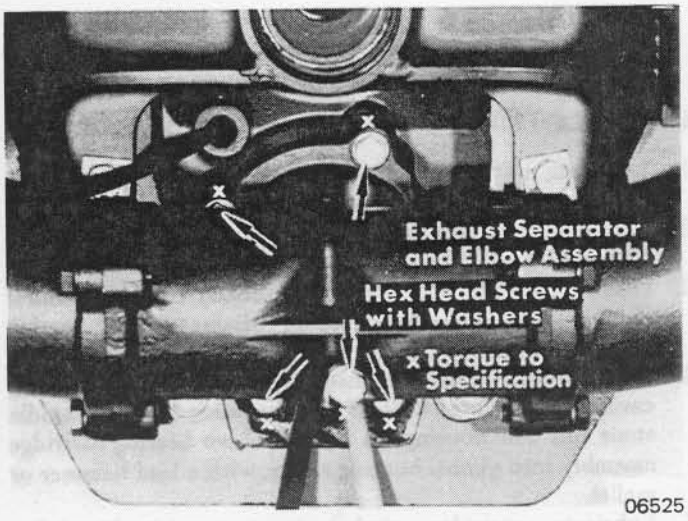


Figure 5. Exhaust Separator and Elbows for V-8 Engines

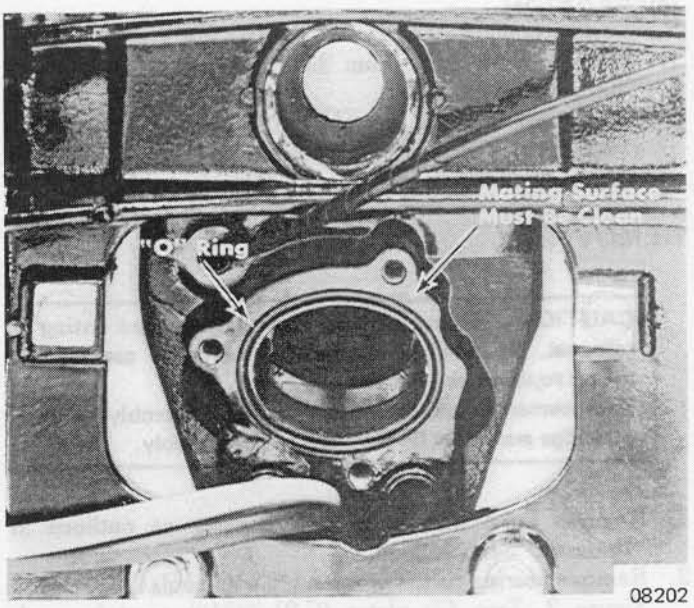


Figure 6. Positioning "O" Ring in Groove on In-Line Engines

INSTALLATION

1. Clean mating surfaces on elbow and gimbal housing.
2. Place "O" ring in groove of gimbal housing. (Figures 6 and 7)
3. Reinstall elbow with screws and lockwashers, torquing them to specification. Be certain that "O" ring remains seated in groove, properly sealing joint to prevent leakage.

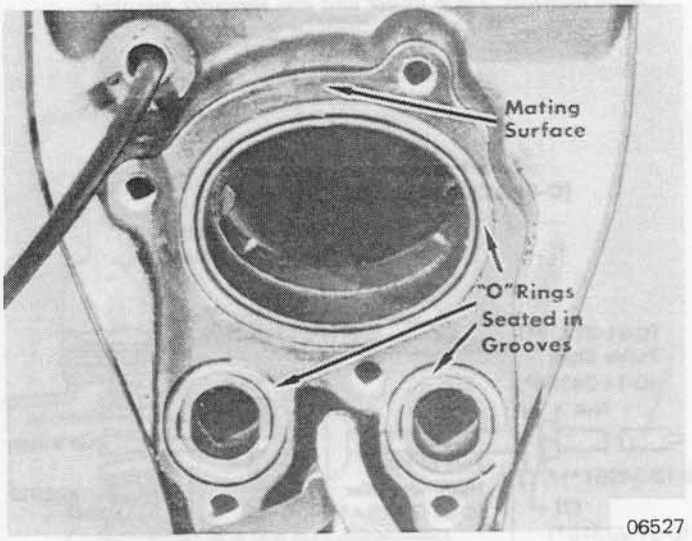


Figure 7. "O" Ring Locations for V-8 Engines

TRIM LIMIT SWITCH and TRIM POSITION SENDER

NOTE: Trim limit switch (marked "TL") is located on port (left) side of gimbal ring, and trim position sender (marked "TP") is located on starboard (right) side of gimbal ring. If Power Package is not equipped with trim position gauge, trim position sender will be substituted with an empty sender housing which will NOT be marked with a "TP".

TESTING

Refer to Section 3-D, "Instrumentation".

REMOVAL

1. Remove switch and/or sender from gimbal ring by removing 2 screws with lockwasher and retainer. (Figure 8)
2. Remove 2 wires from back of switch and/or sender. (Figure 9)

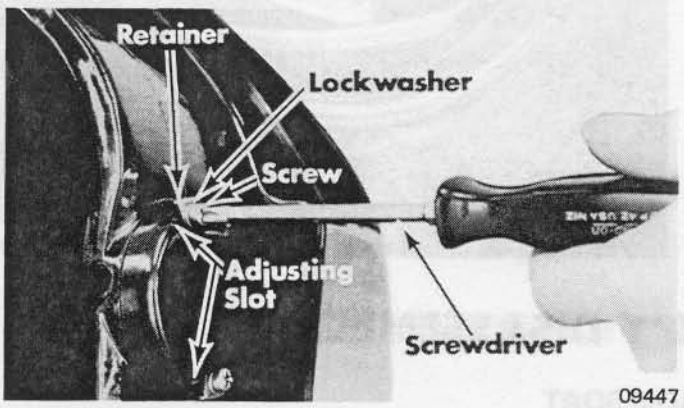


Figure 8. Trim Switch and/or Sender Assembly

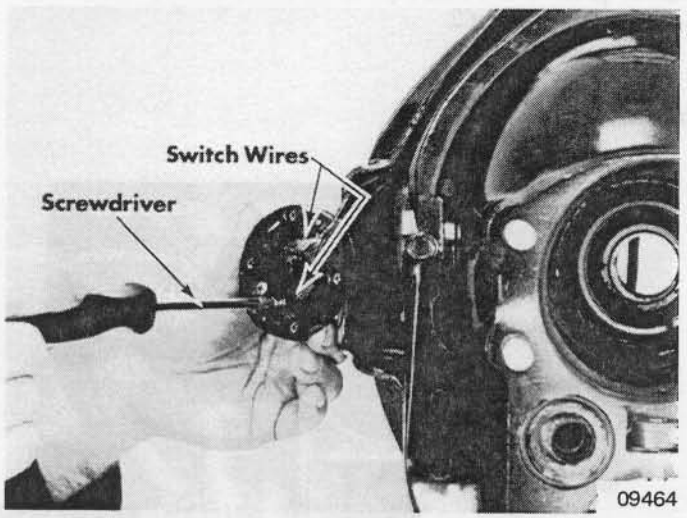


Figure 9. Switch and/or Sender Wires

INSTALLATION

1. Fasten wires securely to back of switch and/or sender. (Figure 9) Torque retaining screws to specifications. Fill grooves with Anti-Corrosion Lubricant (C-92-74048). Be sure that the screws are completely covered.
2. Align slots in insulator and position insulator on back of housing assembly.

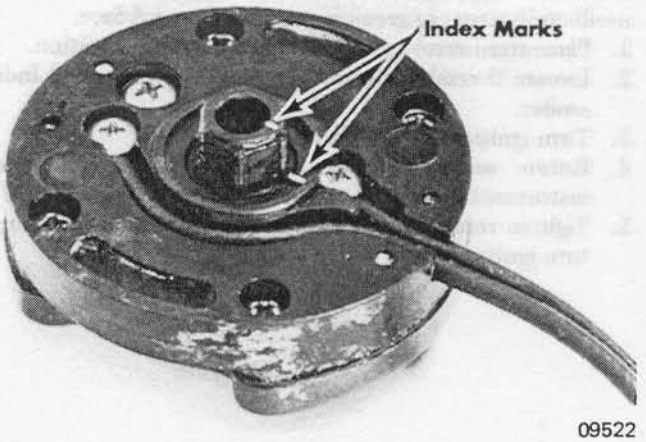


Figure 10. Index Marks Aligned

3. Align rotor index with housing index (Figure 10) and install on gimbal ring with bell housing in "Down" position.
4. Install 2 screws with lockwashers and retainers. (Figure 8)

TRIM LIMIT SWITCH ADJUSTMENT

Limiting drive unit outward trim travel is necessary to ensure safe control of boat at high speeds and to prevent damage to drive unit or trim cylinders because of lost side support to drive unit.

1. Trim drive unit upward until front edge drive shaft housing of drive unit is protruding ¾" to 1" (19mm to 25.4mm) into gimbal ring support bosses, as shown in Figure 11.
2. Disconnect limit switch leads from harness (inside boat) and connect leads to continuity meter.
3. Loosen retaining screws which hold trim limit switch.
4. Switch is normally in closed circuit position. Rotate switch housing in either direction until switch circuit just opens.
5. Tighten retaining screws and reconnect switch leads to complete adjustment.

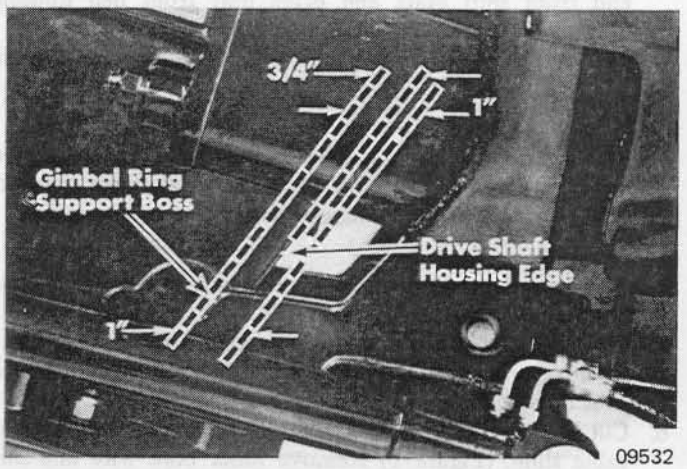


Figure 11. Trim Limit Switch Adjustment

TRIM POSITION SENDER ADJUSTMENT (Accessory)

The following procedure is for fine adjustment of instrument needle to bottom of green area on instrument face.

1. Place stern drive unit in full "Down" trim position.
2. Loosen 2 retaining screws (Figure 2) which hold Indicator sender.
3. Turn ignition key to "Run" position.
4. Rotate sender housing in either direction to position instrument needle on bottom of green arc. (Figure 12)
5. Tighten retaining screws. Recheck instrument reading and turn ignition key to "Off" position.

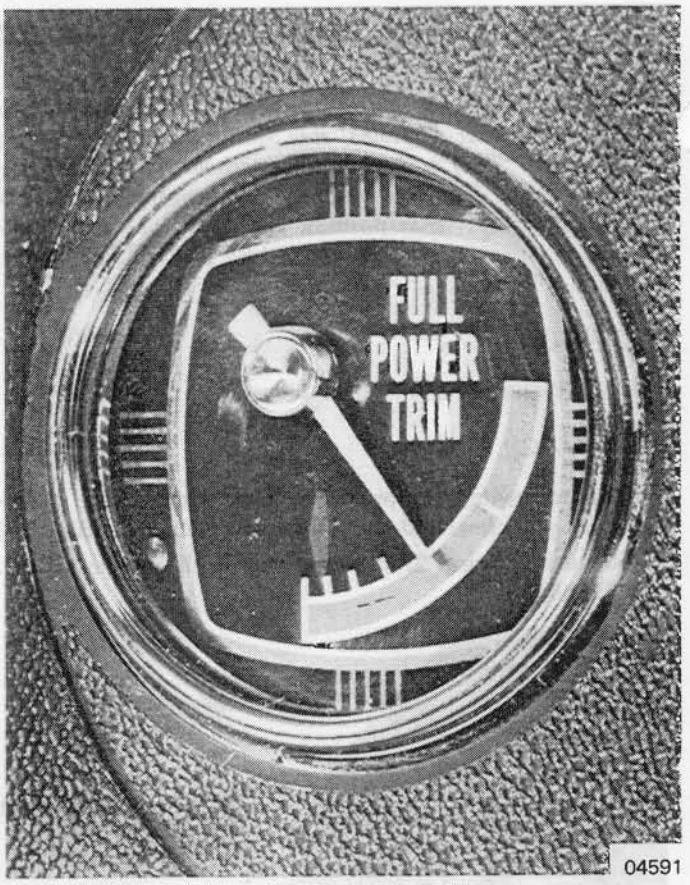


Figure 12. Trim Indicator Instrument

OUTER TRANSOM ASS'Y DISASSEMBLY

REMOVAL FROM BOAT

Remove gimbal housing and transom plate from boat by referring to "Removal-Installation-Alignment" Section 2.

SHIFT CABLE

REMOVAL

NOTE: Shift cable can be removed with transom assembly installed in boat or removed from boat.

1. If transom assembly is installed in boat, remove shift cable end from shift plate and drive unit from bell housing. Refer to "Removal-Installation-Alignment" Section 2.
2. Remove set screws from cable end guide and remove end guide. (Figure 1)

NOTE: If cable is to be reused, burrs (made by set screws) must be removed from core wire so that inner lining of shift cable will not be damaged when wire is removed.

3. Loosen jam nut on metal cable end and turn metal end out of cable. (Figure 1)
4. Pull support tube from end of inner core wire.
5. Remove protective wrapping from shift cable (where cable goes through transom).
6. Cut lockwire and remove allen set screw from end of shift cable slide. (Figure 1) Remove inner core wire and shift cable slide.

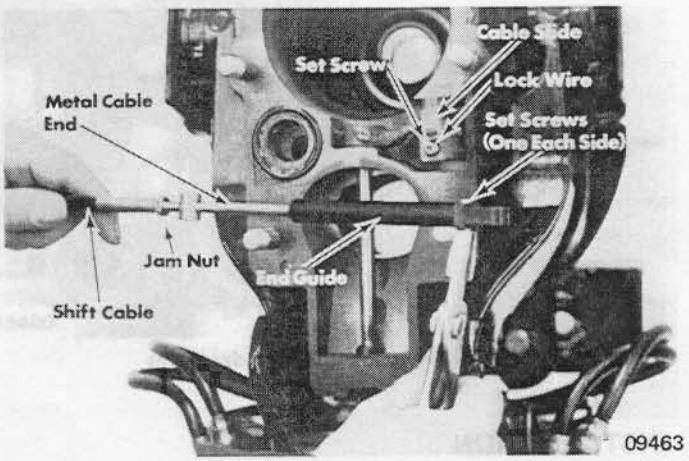


Figure 1. Removing Shift Cable

7. Remove clamp from aft (rear) end of shift cable bellows. (Figure 2)
8. Shift cable can be removed from bell housing at this time, however, shift cable is more easily removed after bell housing has been removed from gimbal ring.

CLEANING and INSPECTION

1. Inspect shift cable for cuts or damage caused by cable which is bent too short or is pinched.
2. Check cable metal end for damaged threads and bent condition.
3. Inspect inner core wire for damage and unraveling at end of wire.

BELL HOUSING

REMOVAL

NOTE: Bell housing can be removed with gimbal housing installed on boat.

1. Remove shift cable. See instructions, preceding.
2. Care must be taken when removing bellows so that bellows are not punctured. If bellows are being replaced, they may be cut and removed from housings after bell housing is removed. Loosen clamp and remove bell housing end of exhaust bellows. (Figure 2) Loosen clamp and remove gimbal housing end of universal joint bellows. A block of wood may be used to hold bell housing in tilted-up position while loosening hose clamps.

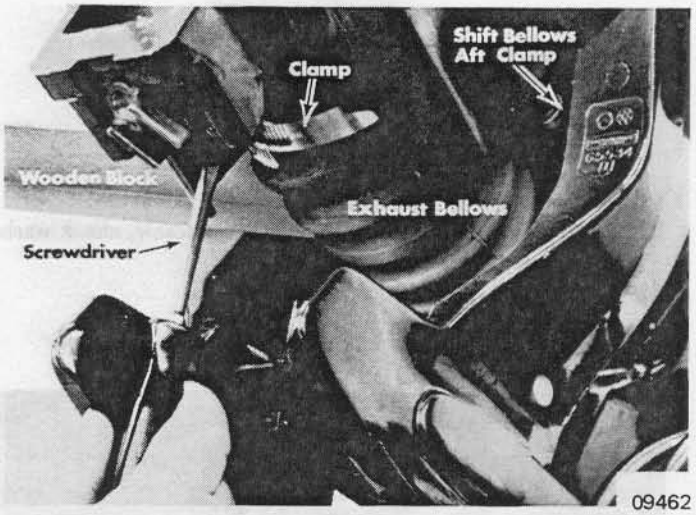


Figure 2. Removing Bellows

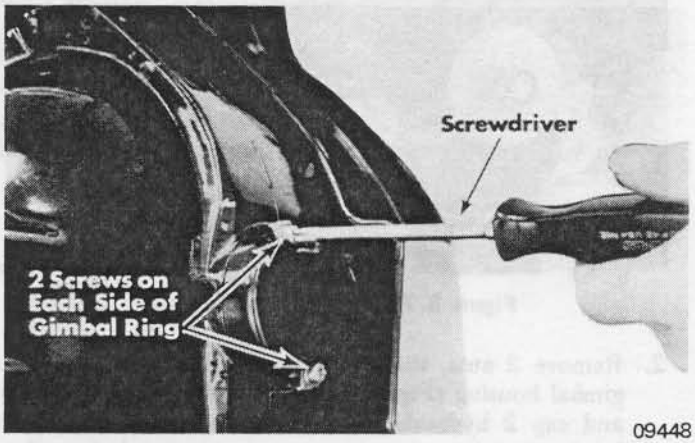


Figure 3. Removing Trim Limit Switch and/or Trim Position Sender

3. Remove 4 screws (2 from each side) and lift trim limit switch and trim position sender from gimbal ring (one each side). (Figure 3)

NOTE: If trim indicator is not installed in boat, an empty trim position sender housing will be installed on starboard side of gimbal ring. Removal is the same.

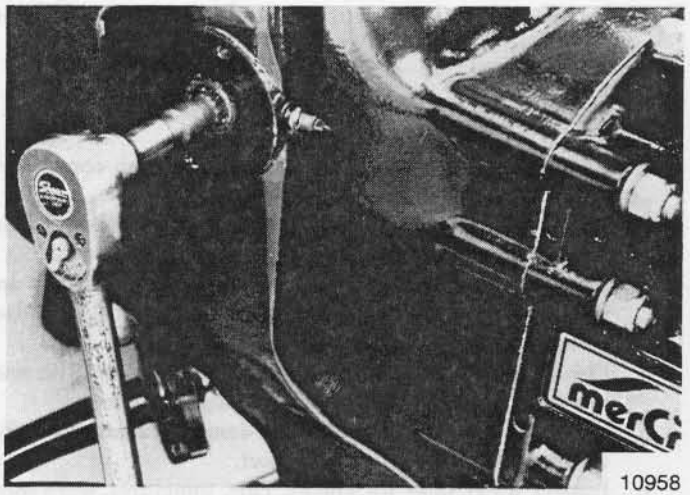


Figure 4. Removing Hinge Pins

4. Position switch and sender assembly so that they will not become damaged during further disassembly.
5. Remove 2 screws, water tube cover and rubber bushing (located at front of gimbal housing) and push water tube thru gimbal housing.
6. Remove gimbal ring to bell housing hinge pins (one each side) with Hinge Pin Tool (C-91-78310). (Figure 4)
7. Remove bell housing assembly.

DISASSEMBLY

1. Remove universal joint bellows, water hose and shift cable from bell housing. (Figure 5)
2. Remove rubber bumper, if replacement is necessary. (Figure 5)

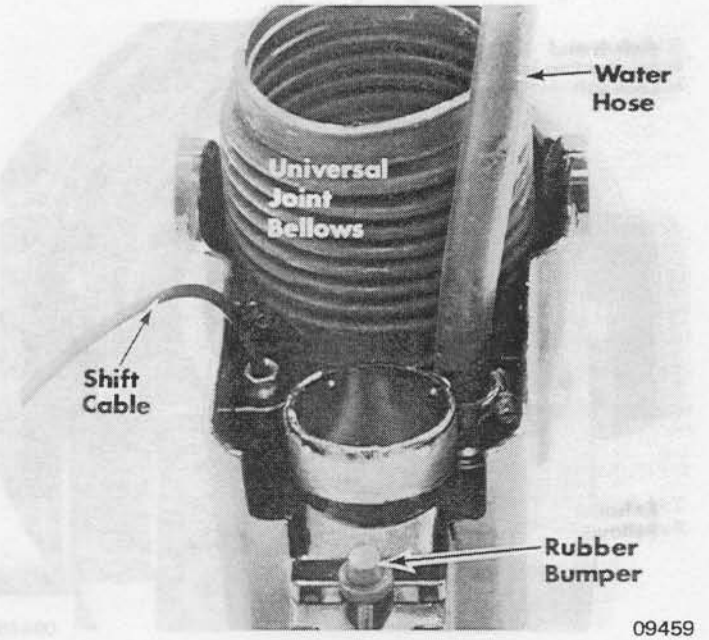


Figure 5. Front End of Bell Housing

3. It may be necessary to apply heat to shift lever screw to break down Loctite which was used in assembly. Use care when applying heat so that shift shaft oil seal (Figure 6) is not damaged. Remove shift lever screw, then remove shift lever, washer and shift shaft. (Figure 6)
4. Remove shift shaft oil seal and bushing (Figure 6), if replacement is necessary.
5. Remove "O" ring (located around water passage) and rubber gasket (located in universal joint passage). (Figure 6)

CLEANING and INSPECTION

1. Clean all metal parts in solvent and dry with compressed air.
2. If bellows is to be re-used, remove bellows adhesive from inside diameter of bellows with lacquer thinner.
3. Inspect bellows carefully for cracks, cuts, punctures and flexibility. If bellows serviceability is doubtful, replace bellows.
4. Clean bellows mounting flanges of bell housing with wire brush or sandpaper, then wipe with lacquer thinner.
5. Check shift cable for cuts or damage caused by cable which is pinched or bent too short.
6. Inspect water hose for cracks, cuts, punctures, worn spots from rubbing and flexibility.
7. Inspect shift shaft oil seal for tears, wear or roughness.
8. Check shift shaft and shift shaft bushings for wear.
9. Check "O" ring and rubber gasket for cuts, nicks, hardness and cracks.
10. If shift lever roller is worn, replace shift lever assembly.

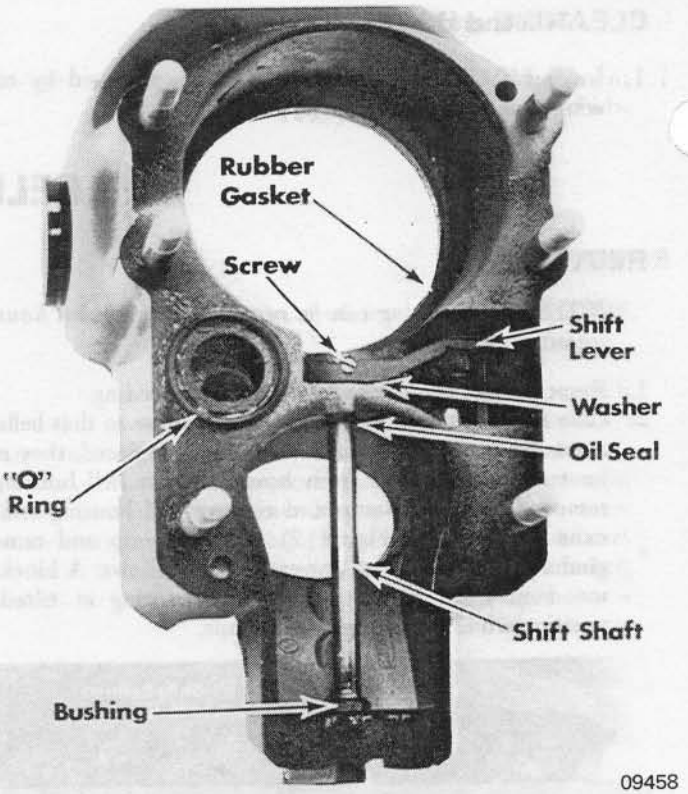


Figure 6. Aft End of Bell Housing

11. Check rubber bumper for damage.
12. If heat was used to remove shift lever screw, check washer under lever for damage.

GIMBAL RING

REMOVAL

NOTE: To remove gimbal ring, transom assembly must be removed from boat.

1. To make gimbal ring removal easier, remove exhaust bellows, trim limit switch and trim position sender leads from gimbal housing. (Figure 7)

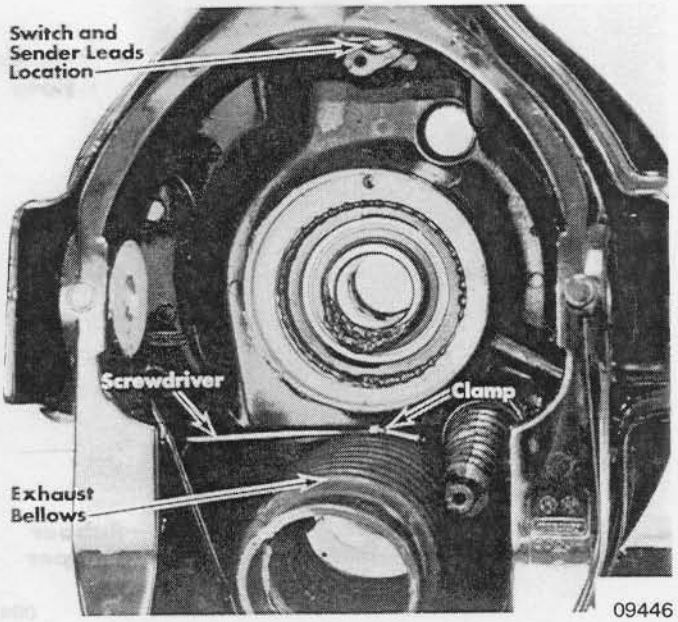


Figure 7. Removing Exhaust Bellows

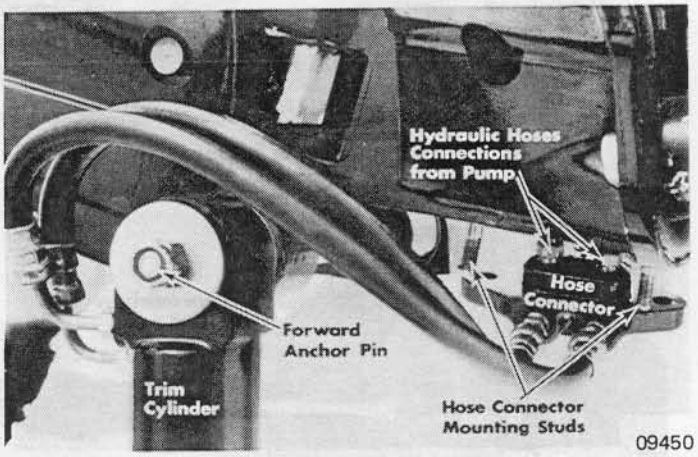


Figure 8. Removing Trim Cylinders

2. Remove 2 nuts, that retain hydraulic hose connector to gimbal housing (Figure 8), and lower connector. Remove and cap 2 hydraulic hoses from top of connector. Plug hose connections in connector to prevent losing oil and keep dirt out of hydraulic system.
3. Remove trim cylinder forward anchor pin and remove trim cylinders with hydraulic hoses attached.
4. Pull out retaining cotter pin, lower swivel pin and washer. (Figure 9)
5. Remove allen head pipe plug (located in bottom end of upper swivel shaft). (Figure 10)

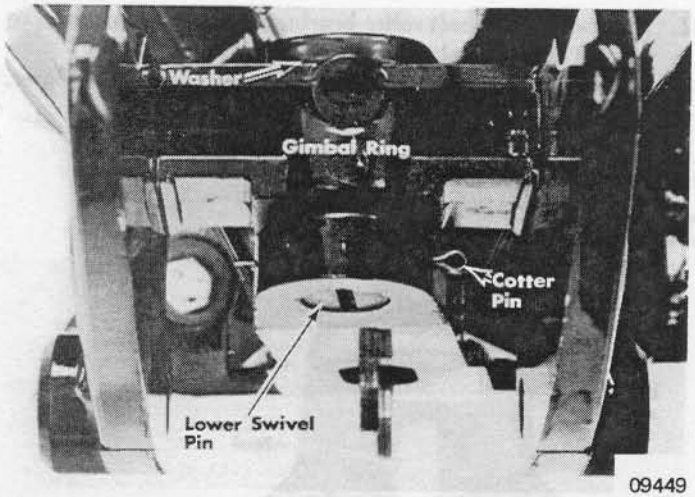


Figure 9. Removing Lower Swivel Pin

6. Remove large nut and washer from top of upper swivel shaft and nut and bolt thru steering lever. (Figure 11)
7. Use Slide Hammer Puller (C-91-34569A1) and Puller Head (C-91-38919) to pull upper swivel shaft. (Figure 12) Also remove steering lever and washer (located under steering lever).
8. Remove gimbal ring and washer from between gimbal ring and gimbal housing.

CLEANING and INSPECTION

1. Clean gimbal ring and bearings in solvent and dry with compressed air.
2. Check surface of lower swivel pin in area where needle bearing rides. Pitting, grooves and uneven wear are causes for bearing and swivel pin replacement.
3. Inspect oil seals for wear, tears and roughness on lip surface.
4. Check gimbal ring to bell housing anti-friction washers for wear.

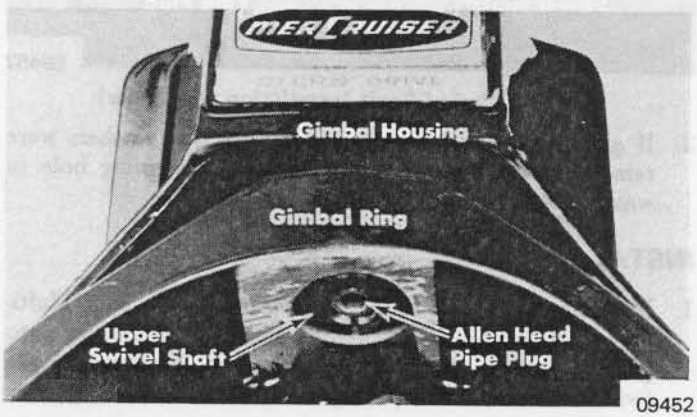


Figure 10. Upper Swivel Shaft and Allen Screw

DISASSEMBLY

1. Drive or press lower swivel pin roller bearing and 2 oil seals out of gimbal ring with Driver (C-91-33492).

   NOTE: Oil seals may be pried out of gimbal ring without removing bearing, if bearing replacement is not necessary.

2. Remove gimbal ring to bell housing anti-friction washers, if replacement is necessary.

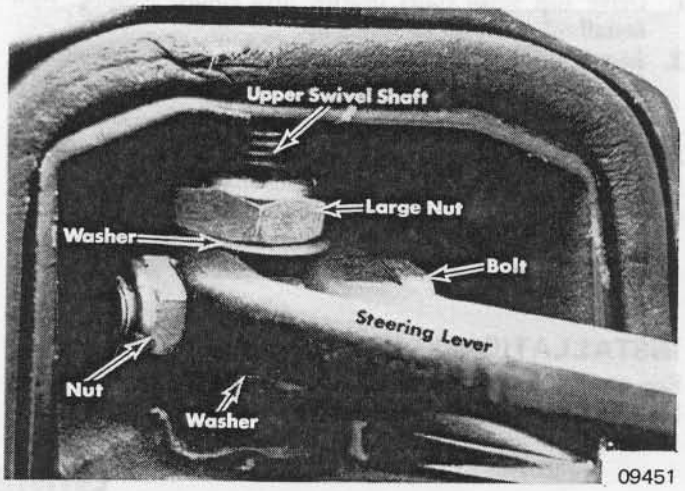


Figure 11. Upper Swivel Shaft and Steering Lever

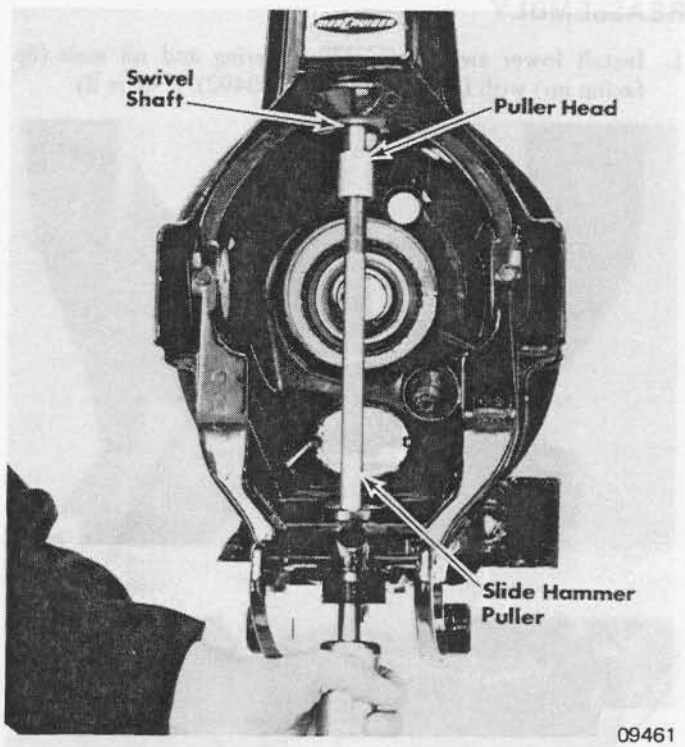


Figure 12. Removing Upper Swivel Shaft

GIMBAL HOUSING

REMOVAL

To remove gimbal housing from transom, refer to "Removal-Installation-Alignment" Section 2.

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air.
2. Check gimbal housing ball bearing by rotating inside race of bearing and by checking for rough spots. Check bearing for side wear. Pull and push on inner race. Any excessive movement is cause for replacement.
3. To check upper swivel shaft roller bearings, inspect area of swivel shaft where bearings ride. Pitting, grooves and uneven wear are causes for bearing and swivel shaft replacement.

DISASSEMBLY

1. To remove gimbal housing ball bearing, refer to "Gimbal Housing Ball Bearing Removal" (see "Index").
2. If upper swivel shaft roller bearing needs replacement, split bearing case with chisel and pry bearing out.
3. Remove 2 screws from water tube cover and remove cover, rubber bushing and water tube.

OUTER TRANSOM ASS'Y REASSEMBLY

GIMBAL HOUSING

1. Drive top small roller bearing into gimbal housing, then install oil seal with lip facing up.
2. Install oil seal (lip facing up), larger roller bearing and second oil seal (lip facing up) with Driver (C-91-33491). (Figure 1)
3. For gimbal housing ball bearing installation, refer to "Gimbal Housing Ball Bearing Installation" (see "Index").
4. Trim limit switch leads, trim position sender leads, exhaust and shift bellows will not be installed at this time to allow easier installation of gimbal ring. Refer to "Bell Housing - Installation".

INSTALLATION

For gimbal housing installation to boat, refer to "Removal-Installation-Alignment" Section 2.

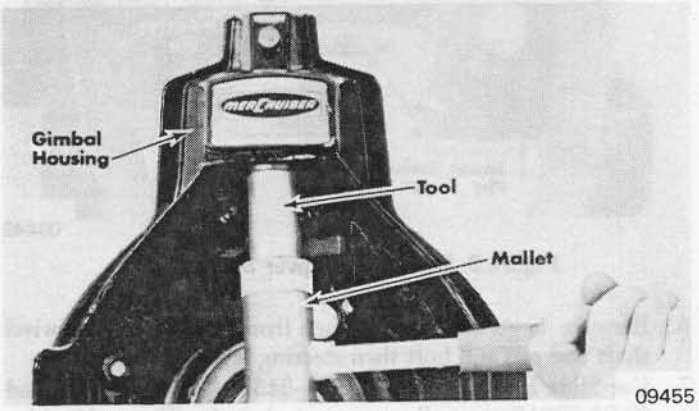
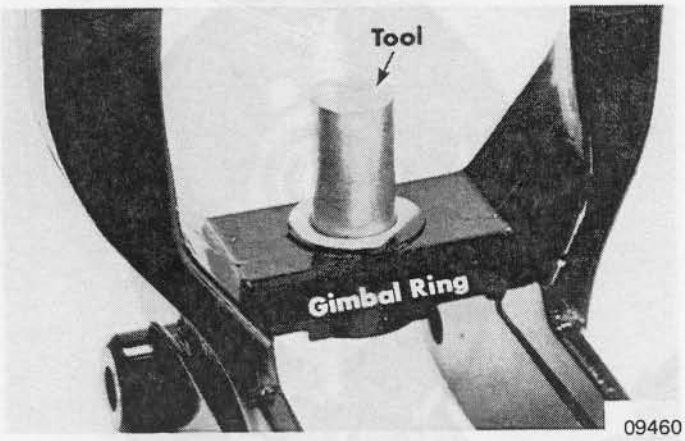


Figure 1. Installing Seals and Roller Bearing

GIMBAL RING

REASSEMBLY

1. Install lower swivel pin roller bearing and oil seals (lip facing up) with Driver Tool (C-91-33492). (Figure 2)



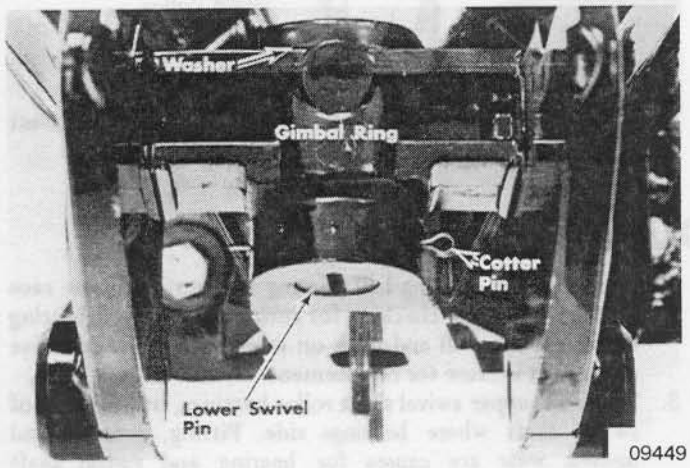


Figure 3. Installing Lower Swivel Pin

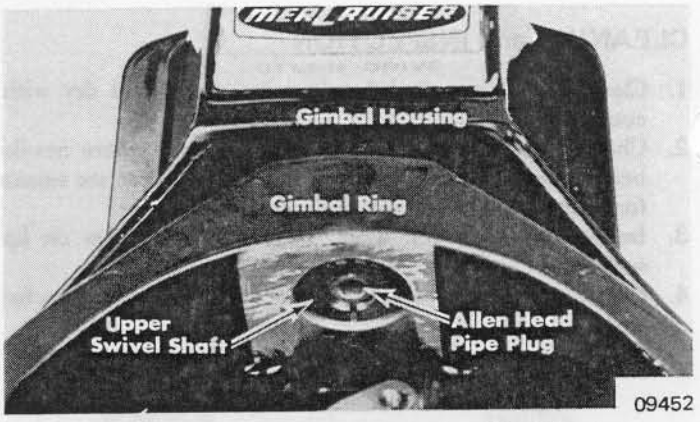


Figure 4. Swivel Shaft Installation (Aft View)

2. If gimbal ring to bell housing anti-friction washers were removed, epoxy new washers in place, aligning hole in washer with hole in gimbal ring.

INSTALLATION

1. Lubricate lip of oil seals and bearing rollers with Multi-purpose Lubricant (C-92-63250). Position gimbal ring onto gimbal housing and install washer and lower swivel pin (with slotted end down). (Figure 3)
2. Use screwdriver in slot to turn swivel pin and align cotter pin hole. Install and bend over end of cotter pin. (Figure 3)
3. Lubricate lower swivel pin roller bearing with Multi-purpose Lubricant thru grease fitting (located on side of gimbal ring).
4. Insert upper swivel shaft thru gimbal ring and into (but not thru) gimbal housing. (Figure 4) Position washer and steering arm on gimbal housing (Figure 5) and continue to install swivel shaft thru washer and steering arm. As shaft protrudes thru steering arm,

install washer and nut on shaft. DO NOT tighten nut. Continue shaft installation until bolt can be installed thru steering arm. Install nut on steering arm bolt but do not tighten.

5. Tighten nut on top of swivel shaft (Figure 5) until snap ring (located in groove on swivel shaft) bottoms out on gimbal ring.
6. Install allen head pipe plug (with Perfect Seal) in bottom of swivel shaft. (Figure 4) Tighten plug securely.

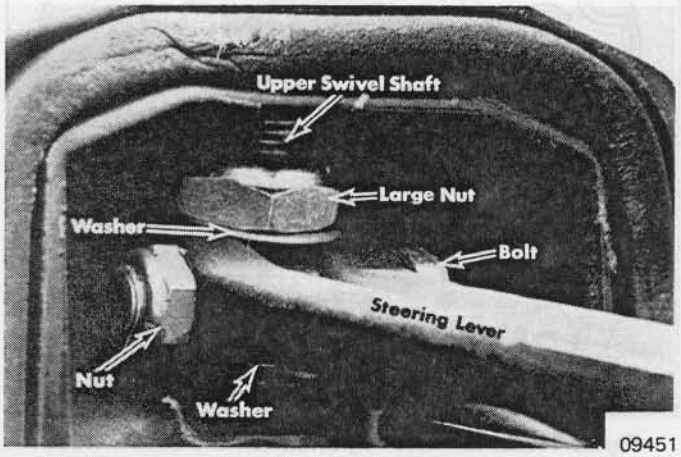


Figure 5. Swivel Shaft Installation (Front View)

7. Loosen nut on top of swivel shaft (Figure 5) to obtain .005" to .007" (.127mm to .178mm) between washer and gimbal housing. (Figure 6)
8. Torque steering arm bolt and nut to specifications (Section 8).
9. Install trim cylinders with cylinder anchor pin. (Figure 7)
10. Install 2 hydraulic hoses to connector (gray hose to aft hole in connector) and install connector to gimbal housing, using 2 internal lockwashers and 2 nuts (not shown). (Figure 7)

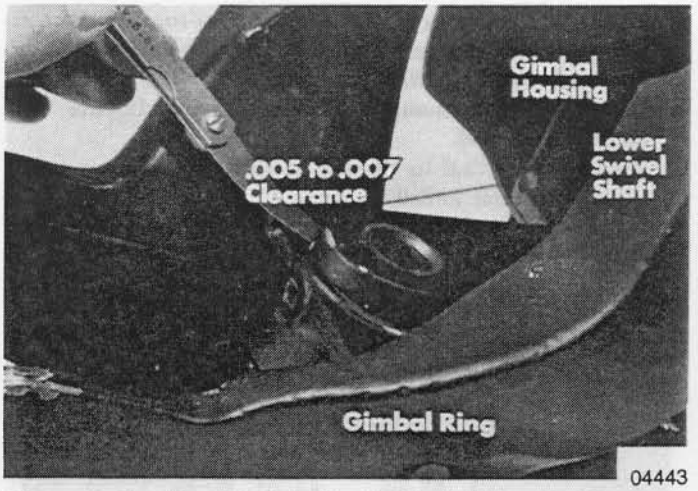


Figure 6. Checking Gimbal Ring to Gimbal Housing Clearance

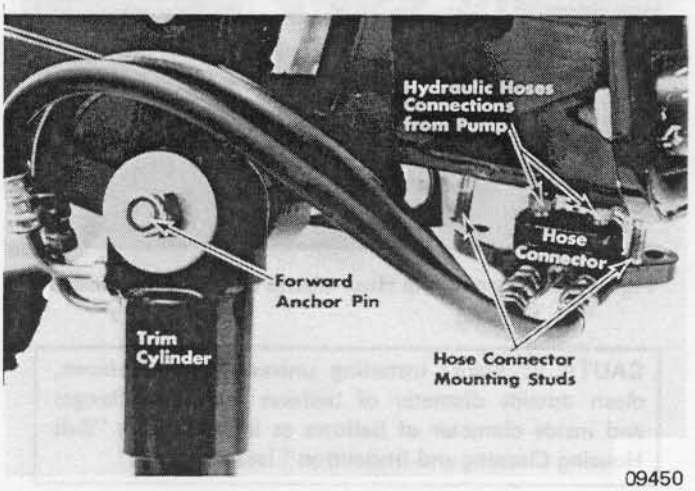


Figure 7. Installing Connector

BELL HOUSING

REASSEMBLY

1. Install shift shaft bushing flush with bottom of housing. (Figure 8)

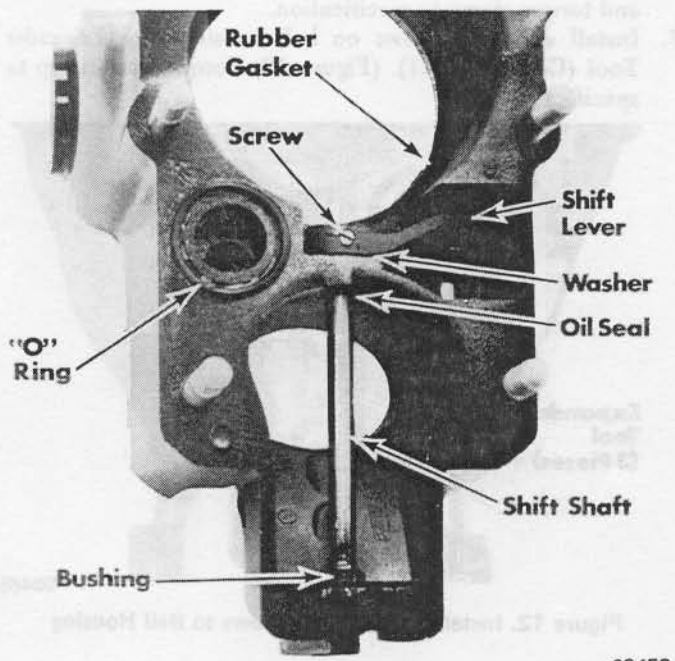


Figure 8. Bell Housing (Aft End)

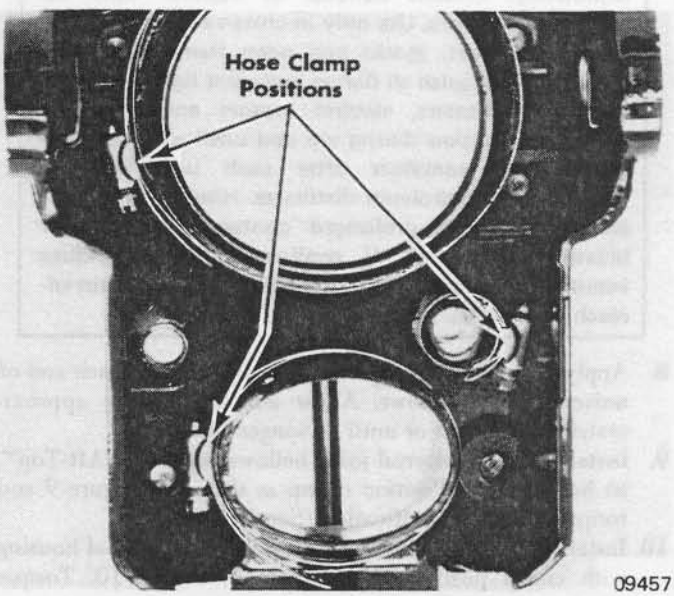


Figure 9. Approximate Hose Clamp Position on Bell Housing

2. Install shift shaft oil seal with lip facing down. (Figure 8)
3. Position shift shaft, washer and shift lever in bell housing. (Figure 8) Apply a drop of Loctite "A" on threads of shift lever retaining screw. Install screw thru shift shaft and into shift lever.

4. Install "O" ring around water passage and rubber gasket in universal joint passage. (Figure 8) Use a general adhesive to hold gasket and "O" ring in place.
5. Install new rubber bumper (if removed), using Loctite "A" on threads of stud.
6. Apply Perfect Seal to threads of shift cable adaptor and install shift cable to bell housing.
7. Install water hose to bell housing with clamp positioned, as shown in Figure 9.

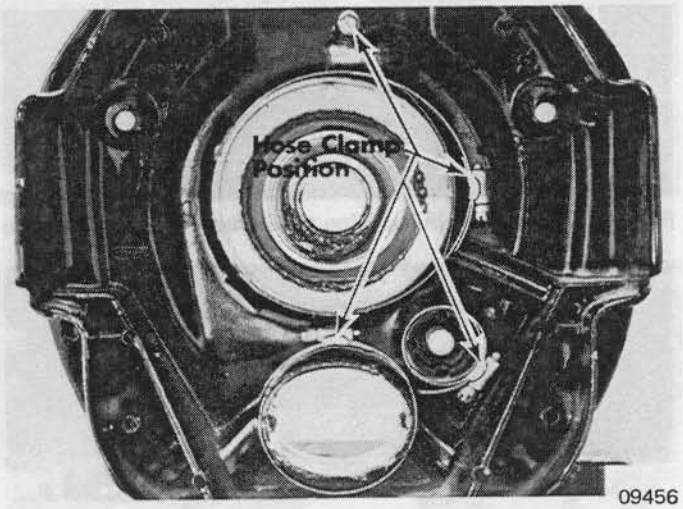


Figure 10. Approximate Hose Clamp Position on Gimbal Housing

CAUTION: Before installing universal joint bellows, clean outside diameter of bellows mounting flanges and inside diameter of bellows as illustrated in "Bell Housing Cleaning and Inspection" (see "Index").

WARNING: Extremely Flammable! Vapors from Bellows Adhesive may cause flash fire or ignite explosively. Prevent buildup of vapors. Open all windows and doors. Use only in cross-ventilation. Keep away from heat, sparks and open flame. DO NOT SMOKE. Extinguish all flames and pilot lights and turn off stoves, heaters, electric motors and all other sources of ignition during use and until all vapors are gone. Close container after each use. Contains TOLUOL and petroleum distillates. Harmful or fatal if swallowed. Avoid prolonged contact with skin or breathing of vapors. If swallowed, do not induce vomiting. Call physician immediately. Keep out-of-reach of children.

8. Apply Bellows Adhesive to inside diameter of each end of universal joint bellows. Allow adhesive to dry approximately 10 minutes or until no longer tacky.
9. Install end of universal joint bellows, marked "Aft-Top", to bell housing. Position clamp as shown in Figure 9 and torque clamp to specification (Section 8).
10. Install exhaust bellows and shift bellows to gimbal housing with clamp positioned as shown in Figure 10. Torque clamp to specification.
11. Position trim limit switch and trim position sender leads thru gimbal housing and install retaining cover. Tighten screws securely. Position sender and switch wires behind water hose, as shown in Figure 11.

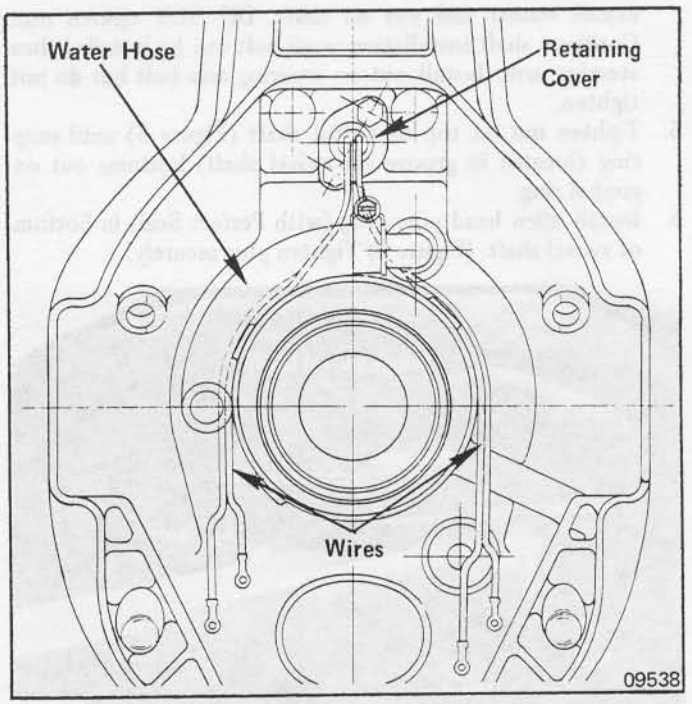


Figure 11. Correct Routing of Switch and Sender Wires

INSTALLATION

1. Insert shift cable end thru shift cable bellows. Multi-purpose Lubricant may be used to ease installation.
2. Position water hose tube (attached to water hose) thru gimbal housing with tube end facing upward and slightly tilted to port (left) side for 8-cylinder engine. Face tube end toward starboard (right) side, slightly tilted up from a horizontal position, for 6-cylinder engine.

IMPORTANT: Trim position sender and limit switch wires MUST BE positioned as shown in Figure 11.

5. Apply Locquick Primer and Loctite No. 35 to threads of hinge pins, install and torque to specifications.
6. Check position of universal joint bellows on gimbal housing mounting flange, to be sure of proper installation, and torque clamp to specification.
7. Install exhaust bellows on bell housing with Expander Tool (C-91-45497A1). (Figure 12) Torque hose clamp to specification.

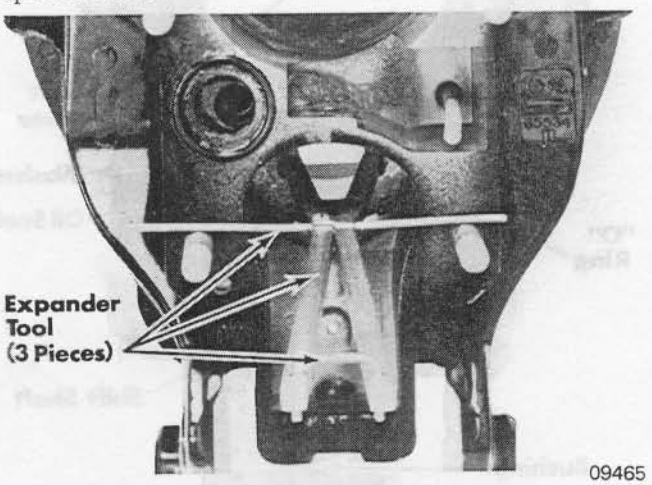


Figure 12. Installing Exhaust Bellows to Bell Housing

INSTALLATION

NOTE: If cable was installed to bell housing previously, omit Step 1.

1. If shift cable is being replaced without removal of bell housing, insert cable end thru aft end of shift cable bellows, using Multipurpose Lubricant to ease installation. Lift up on bottom of bell housing and insert cable end (with connector) thru bell housing opening. Apply Perfect Seal to threads of cable connector and thread cable into bell housing. Tighten connector securely.
2. Install clamp on rear end of shift cable bellows. End of bellows must be approximately 2" (51mm) from cable connector (located in bell housing). Squeeze clamp securely to prevent water from entering bellows.
3. Turn cable end into shift cable (Figure 13) until it bottoms out, then tighten jam nut.
4. Install cable slide and inner core wire. (Figure 13)
5. Install allen set screw in cable slide. Tighten set screw securely, then back off approximately ¼-turn. The screw must be loose enough to permit core wire to turn or rotate freely, but tight enough to minimize end play between cable and cable slide. Secure screw with lockwire.

IMPORTANT: If new inner core wire is being installed, wire must be cut to specified length. Refer to Section 2, "Shift Cable Installation and Adjustment".

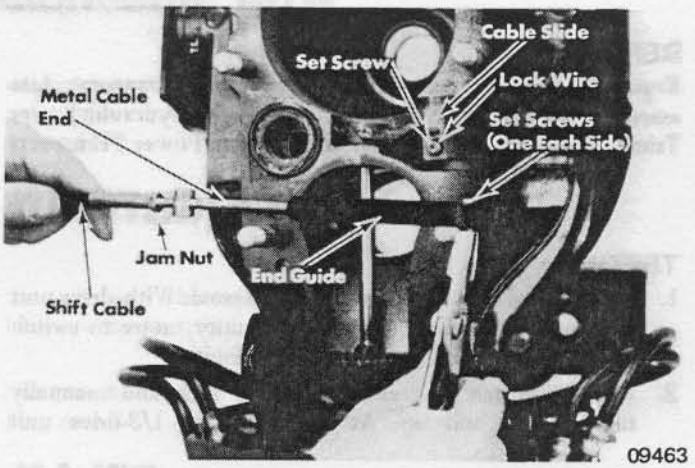


Figure 13. Installing Shift Cable

6. Install support tube on end of inner core wire approximately ½" (12.7mm) from end of wire. Crimp support tube to secure its position on core wire.
7. Install end guide on cable and tighten set screws securely. (Figure 13)
8. Place protective wrapping on shift cable in area where cable extends thru transom.
9. Install drive unit and adjust shift cables. Refer to "Removal-Installation-Alignment" Section 2.

MANUAL TRIM TRANSOM PLATE ASSEMBLY
With Side-Mounted Rotary Switch

REPAIR

Repair procedures for manual trim model transom plate assembly are similar to previous model with "hydraulic Power Trim", preceding, except that all hydraulic Power Trim parts have been eliminated. A mechanical reverse lock assembly, cutout switch and relay have been added, for which repair procedures follow. For complete disassembly and reassembly, refer to transom plate repair, preceding.

TILT (CUTOUT) ROTARY SWITCH

TESTING

1. Switch need not be removed to be tested. With drive unit in "Down" position, connect continuity meter to switch wires. Meter should indicate NO continuity.
2. Actuate switch by releasing reverse lock and manually tilting drive unit up. At approximately 1/3-drive unit upward travel, switch should close and meter should indicate full continuity.

REMOVAL and INSTALLATION

Refer to "Trim Limit Switch" removal and installation, preceding.

RELAY SOLENOID

TESTING

1. Connect ohm meter across solenoid small terminals with wires removed from terminals.
2. An ohm reading of 3.7 to 4.3 indicates a good solenoid. Replace solenoid if not within specifications.
3. Connect continuity meter to solenoid bracket and alternately to solenoid's 4 terminals with wires removed from terminals. There should be no continuity between bracket and any terminals.
4. Connect continuity meter between solenoid large terminals. Momentarily apply a minimum of 4.5 volts (but not more than 12 volts) to solenoid small terminals. Solenoid switch should actuate and meter should indicate full continuity across large terminals.

REVERSE LOCK ASSEMBLY

REMOVAL

1. Remove reverse lock stop screw, washer and spring. (Figure 1)
2. Drive out reverse lock pivot pin.
3. Lift out reverse lock arm assembly.

NOTE: DO NOT remove stop assembly (Figure 1), unless replacement is necessary.

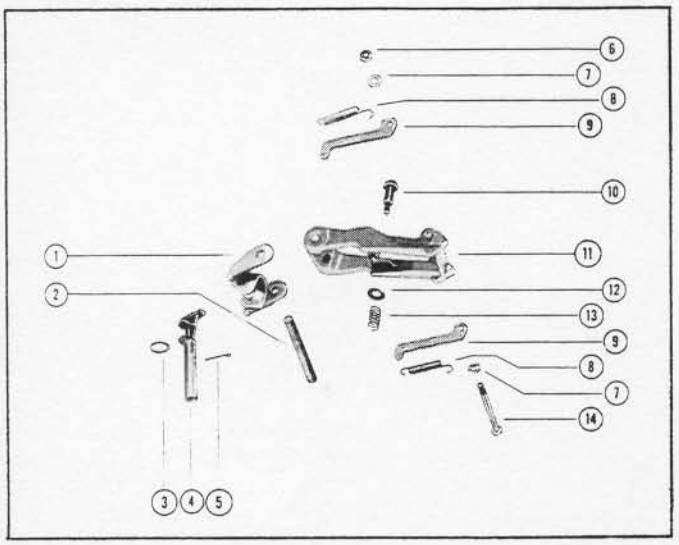


Figure 1. Reverse Lock Assembly and Related Parts

1 - Stop Assembly	8 - Spring (2)
2 - Pivot Pin	9 - Reverse Hook (2)
3 - Washer	10 - Stop Screw
4 - Shift Shaft	11 - Arm Assembly
5 - Cotter Pin	12 - Washer
6 - Nut	13 - Spring
7 - Washer (2)	14 - Bolt

4. If stop assembly removal is necessary, remove gear housing assembly from drive shaft housing. Refer to "Gear Housing Removal" (see "Index").
5. Remove cotter pin, washer and intermediate shift shaft from drive shaft housing.
6. Lift out stop assembly.

CLEANING and INSPECTION

1. Use wire brush to remove any corrosion. Wash parts in solvent and dry with compressed air.
2. Check reverse hooks where they hook over tilt pin (located in gimbal ring) for wear and damage.
3. Check tilt pin for bent condition. Nuts on tilt pin must be slightly loose so that pin can rotate.
4. Inspect surface of stop assembly where stop contacts reverse hooks when shifted into reverse. If surface is worn, replace stop assembly.
5. Check stop assembly nylon roller for wear. Replace stop assembly if needed.

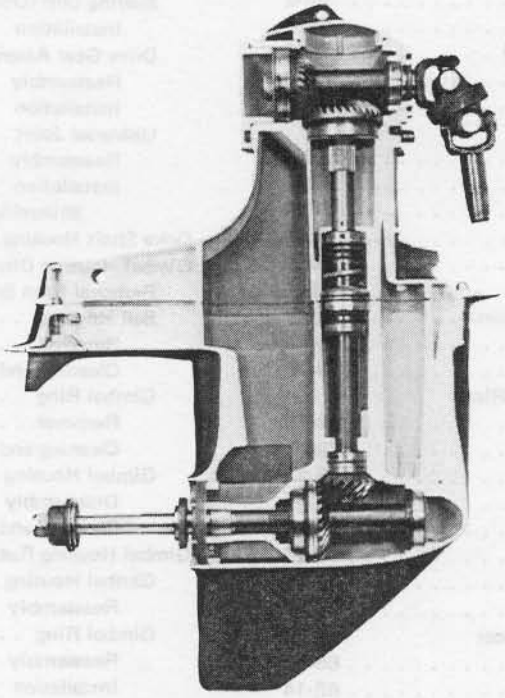
INSTALLATION

1. Place stop assembly in drive shaft housing. DO NOT install pivot pin.
2. Insert shift shaft thru its bushing in drive shaft housing and install washer and cotter pin. Bend open cotter pin.
3. Position arm assembly into drive shaft housing (with reverse hooks facing down), aligning pivot pin holes in stop assembly and arm assembly with holes in drive shaft housing. Install pivot pin and peen drive shaft housing in area around pivot pin holes (on each side) to secure pin.
4. Place spring and washer under arm assembly and install stop screw. Tighten screw until screw shoulder bottoms out on drive shaft housing.
5. Install gear housing assembly. Refer to "Gear Housing Installation" (see "Index").

SECTION 6 - DRIVE SYSTEMS

mercruiser

PART B - MERCRUISER II-TR DRIVE UNIT



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MERCURY MARINE

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MERCRUISER II-TR DRIVE UNIT
SERVICE RECOMMENDATIONS

Instructions are printed in the sequence which will be followed to assure best results when removing or replacing components. Follow "Disassembly" and "Reassembly" procedures as written. If complete disassembly is not necessary, however, start reassembly at point disassembly was stopped. (Use "Index".) In order to assure correct and durable operation after assembly, it is important that all adjustments and torque value specifications be maintained to the highest degree of accuracy.

Use special service tools, where specified, and use common tools of proper fit when removing and replacing parts.

When holding housings or parts in a vise -- or by other means -- use blocks of wood and/or brass shields to prevent marring parts' surfaces. Pressed-on parts (bearings, gears, etc) require adapting appropriate mandrels and supports for the press used. Do not apply force on the bearing cages, mating surfaces or edges which will mar or fail if force is applied.

DO NOT spin bearings with compressed air, as bearings may be damaged, and it can be dangerous.

To prevent corrosive action, apply Perfect Seal (C-92-34227) to external parts of bearing carrier, bearing carrier retainer and housing mating surfaces during reassembly. DO NOT allow sealer to contact "O" rings or enter bearings and gears. To ease installation of drive unit components, apply Multipurpose Lubricant (C-92-63250) to the lip of all oil seals and "O" rings.

To prevent oil leakage, apply Loctite Type "A" (C-92-32609-1) on outside diameter of all metal case oil seals. When using Loctite on oil seals or threads, surfaces must be clean and dry.

Refer to Section 8, "Specifications", for all torque specifications.

Keep a record of shim amounts and location. Be sure to follow shimming instructions closely. Gears must be mounted to correct feeler gauge reading and correct gear backlash to avoid noisy performance and premature failure. Bearing preload must be within specifications, or bearing failure may result.

Threaded parts are right hand (RH), unless otherwise indicated. Drive unit should be completely disassembled, inspected and cleaned, if either gear housing or drive shaft housing has indicated a failure.

A suitable mandrel for pressing tapered roller bearings on shafts and gears can be obtained from the old bearing. Cut outer cage off inner race with hack saw. (Figure A) Remove cage and bearing rollers. Inner race (used as a mandrel) will apply pressing force to inner race of new bearing without damaging bearing cage, rollers or races. Remove bearings from gears or shafts only if replacement is necessary.

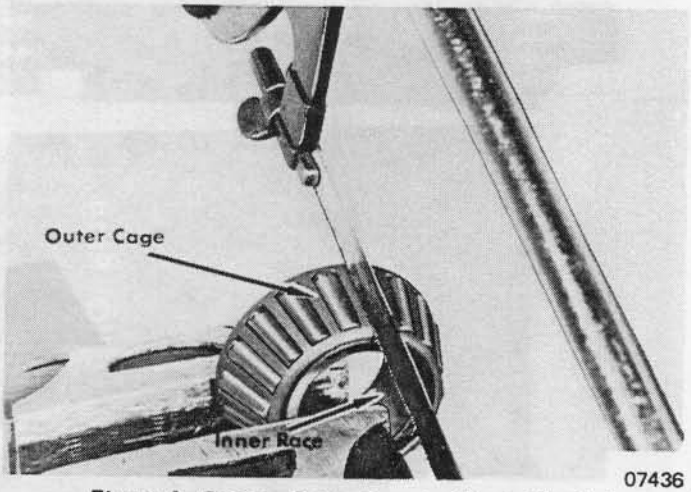

Figure A. Cutting Outer Cage to Obtain Mandrel

GEAR HOUSING ASSEMBLY

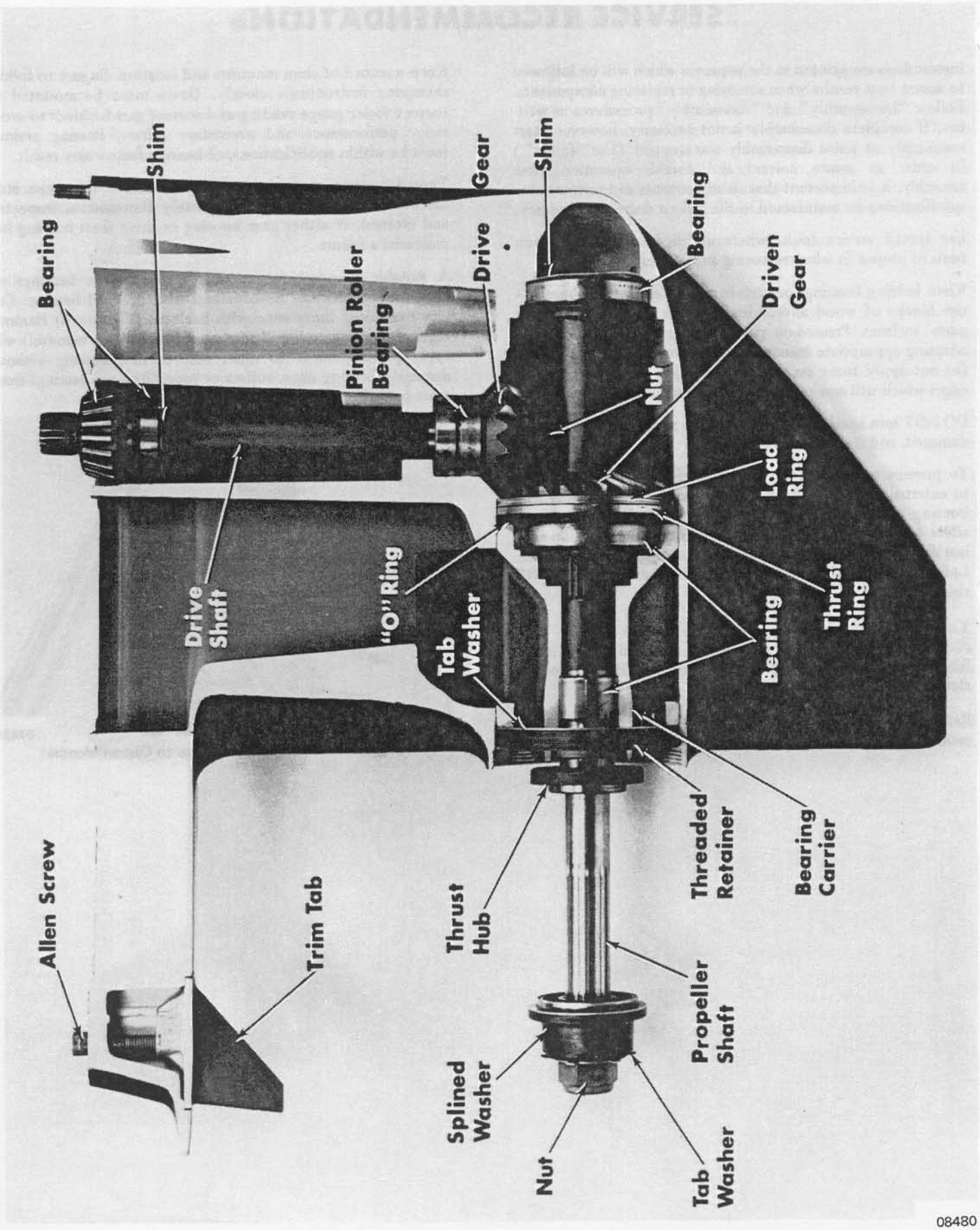

Figure B. Gear Housing Parts Identification (Right Hand Rotation)

GEAR HOUSING REMOVAL

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1. Remove complete drive unit from bell housing as in "Drive Shaft Housing Removal", Section 2.
2. Drain gear lubricant. Check lubricant for metal particles or water.
   a. If metal particles are found, disassemble complete drive unit. Clean all parts in solvent (especially bearings) and dry with compressed air.
   b. If water is found, disassemble complete drive unit. Clean all parts in solvent and dry with compressed air. Apply a light coat of oil to all parts to prevent rusting. Check housings for impact damage and replace all "O" rings and oil seals.
3. Remove propeller and trim tab.
4. Remove allen head screw located under trim tab. Remove 7 nuts and separate gear housing from drive shaft housing.

Figure 1. Draining Lubricant

GEAR HOUSING DISASSEMBLY - RIGHT HAND ROTATION

IMPORTANT: Follow "General Service Recommendations" (see "Index").

BEARING CARRIER (CARRIER RETAINER and TAB WASHER)

IMPORTANT: Before disassembly, position dial indicator on machined surface of propeller shaft just behind bearing carrier. Push propeller shaft to one side and hold in this position while zeroing dial indicator. Move propeller shaft to opposite side. Shaft deflection should be max..003" (.076mm). DO NOT turn propeller shaft. Repeat procedure, moving shaft up-and-down. If shaft deflection is more than .003", shaft and/or needle bearing is worn, or propeller shaft is undersize.

REMOVAL

1. Mount gear housing assembly on Repair Stand (C-91-33750) with Adaptor (C-91-60524A1).
2. Straighten locking tab and loosen threaded retainer with Retainer Tool (C-91-54873). (Figure 1) Remove retainer and tab washer.
3. Remove bearing carrier with Slide Hammer (C-91-34569A1) and Bearing Carrier Puller (C-91-45086A1). (Figure 2) Be careful not to lose carrier alignment key.

Figure 1. Removing Threaded Retainer

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Figure 2. Removing Bearing Carrier

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air. DO NOT allow solvent to remain on oil seals, or seals will become unserviceable.

Figure 3. Propeller Shaft Surface

2. Check propeller shaft bearing cup for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cup and bearing if any of these exist.
3. Inspect oil seals for wear, tears, roughness and proper spring position. If there is any doubt about oil seal serviceability, replace oil seals. Inspect surface of propeller shaft where oil seal lips contact shaft. (Figure 3) Any groove in propeller shaft in this area requires oil seals and shaft replacement.
4. Check needle bearing for serviceability by inspecting bearing contact surface on propeller shaft. (Figure 3) Pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles are reason for bearing and propeller shaft replacement.
5. Check threaded retainer for broken or corroded threads and cracks.
6. Replace tab washer. DO NOT re-use.

DISASSEMBLY

1. Using Slide Hammer Tool (C-91-34569A1), remove tapered roller bearing cup from bearing carrier. (Figure 4)

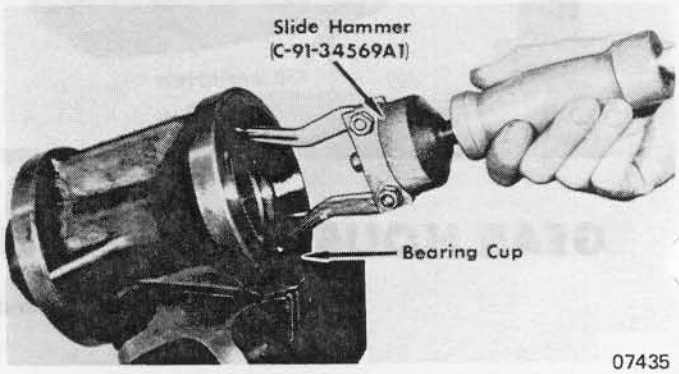

Figure 4. Removing Bearing Cup

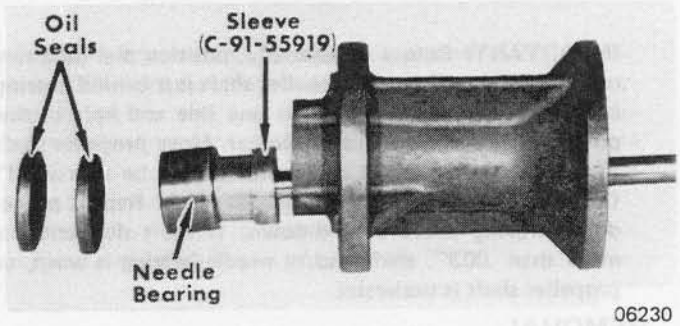

Figure 5. Removing Seals and Bearing

2. Using Sleeve Tool (C-91-55919) and Driver Rod Tool (C-91-37323), remove needle bearing and 2 oil seals from carrier. (Figure 5)

NOTE: Seals can be removed separately with Slide Hammer (C-91-34569A1).

PROPELLER SHAFT ASSEMBLY ("O" RING, THRUST RING and LOAD RING)

LEFT HAND ROTATION VARIATIONS

1. Left hand propeller shaft, front bearing and driven gear bearing have part numbers different than right hand rotation parts. These parts are not interchangeable and are assembled differently, as shown in Figure 6.

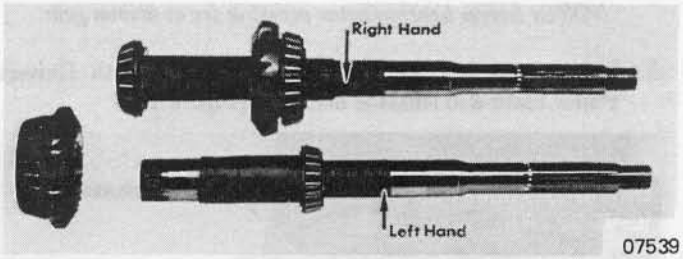

Figure 6. R.H. and L.H. Propeller Shaft Assemblies

2. Driven gear on left hand rotation is not a press fit to propeller shaft and is installed into gear housing before pinion gear is installed. Propeller shaft then is set into driven gear.
3. Gear shimming and preload are adjusted at same locations for left hand and right hand rotation units.

CAUTION: Propeller must be matched to rotation of drive unit.

REMOVAL

1. Lift propeller shaft straight up (about 3 or 4" [7.6 or 10.2cm]) to unseat thrust ring, "O" ring and load ring. Set propeller shaft back into its normal running position in gear housing and lift the "O" ring, thrust ring and load ring out of gear housing.

Figure 7. Removing Propeller Shaft

2. To prevent damaging propeller shaft bearing on pinion gear, tilt propeller end of shaft toward anti-cavitation plate while removing shaft from housing. (Figure 7)

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air.

CAUTION: DO NOT spin bearings with compressed air, as bearings may be damaged.

2. Check propeller shaft tapered roller bearings by inspecting bearing cups. Pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles are all reasons for replacement. Replace both bearing and bearing cup.
3. Inspect propeller shaft where bearing carrier needle bearing rides. (Figure 7) Replace propeller shaft and needle bearing if shaft is pitted, grooved, scored, discolored from overheating, worn uneven or has embedded foreign metal particles.
4. Inspect surface of propeller shaft where bearing carrier oil seal lips contact shaft. (Figure 7) Any groove in shaft in this area requires replacement of shaft and oil seals.
5. Inspect driven gear (right hand rotation) for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear if any of these exist.

NOTE: On left hand rotation, pinion gear and drive shaft must be removed before removal of driven gear.

6. Check propeller shaft for straightness:
   a. Place propeller shaft on balance wheels and spin shaft. Observe shaft for wobble on propeller end of shaft. Replace if bent.
   b. Place propeller shaft on "V" blocks. Rotate shaft. If propeller end of shaft wobbles, replace shaft.
   c. Place shaft between centers in lathe. Place dial indicator in area of needle bearing. If total indicator variation is greater than .005" (.127mm) as shaft is revolved, replace shaft.
7. Clean all corrosion from propeller shaft splines. If splines are partially corroded away, replace shaft.
8. Inspect "O" ring for cuts, nicks, hardness and cracks. If there is any doubt about "O" rings serviceability, replace "O" ring.
9. If gear housing or any internal gear housing components have been changed, a NEW load ring must be used.

DISASSEMBLY (Right Hand Rotation)

NOTE: For left hand rotation propeller shaft differences refer to "Left Hand Rotation Variations" (see "Index").

1. Press driven gear and bearing assembly from propeller shaft with Universal Puller Plate Tool (C-91-37241). (Figure 8)

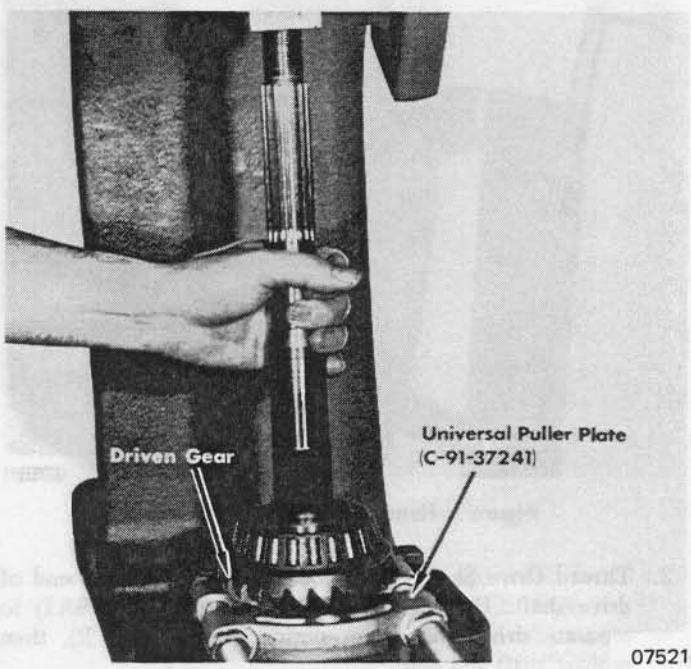

Figure 8. Removing Propeller Shaft from Driven Gear

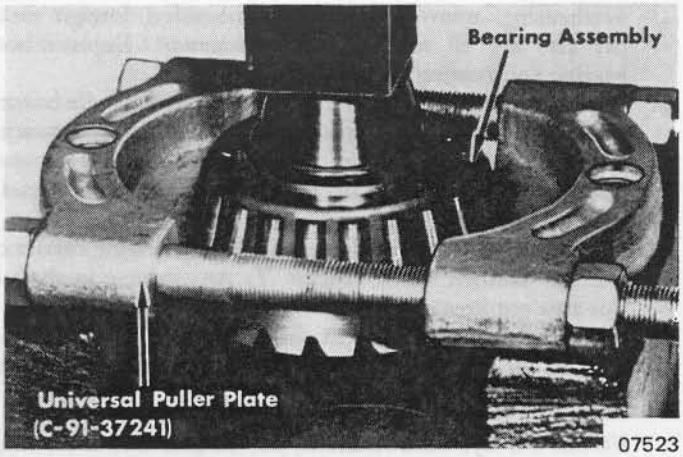

Figure 9. Removing Bearing from Driven Gear

NOTE: Remove bearing from gear only if replacement is necessary.

2. Using Universal Puller Plate Tool and suitable mandrel, press driven gear bearing from driven gear. (Figure 9)

NOTE: Scrap bearing after pressing from driven gear.

3. Press front bearing from propeller shaft with Universal Puller Plate and suitable mandrel. (Figure 10)

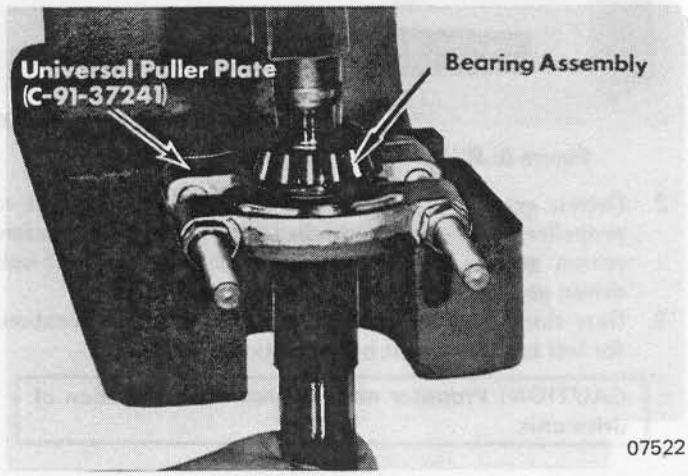

Figure 10. Removing Front Bearing from Shaft

DRIVE SHAFT ASSEMBLY and PINION GEAR

REMOVAL

1. Reinstall carrier retainer nut to protect threads in housing. Use Drive Shaft Socket Tool (C-91-63620A1) and remove pinion gear nut and washer. (Figure 1)

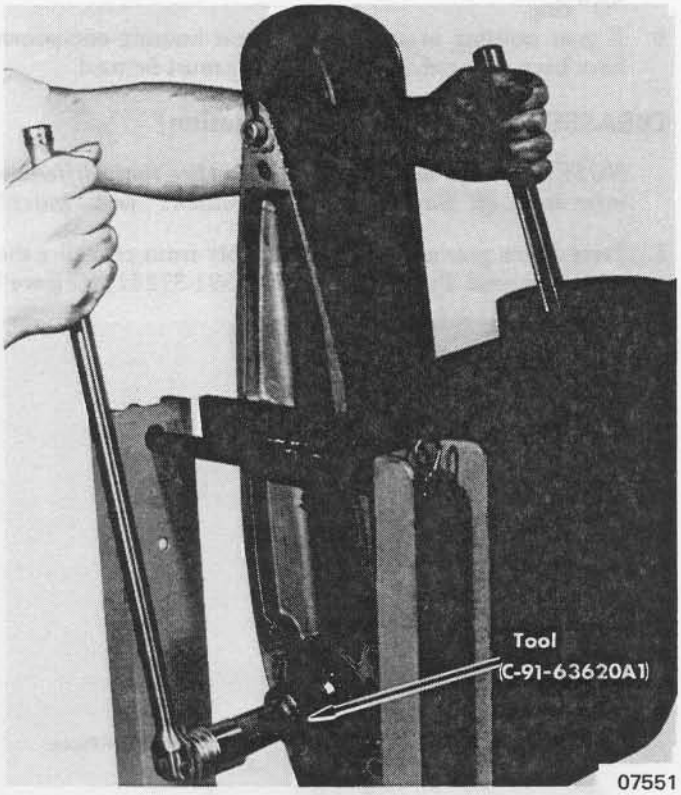

Figure 1. Removing Pinion Gear Nut

2. Thread Drive Shaft Puller Tool (C-91-63616) into end of drive shaft. Use Slide Hammer Tool (C-91-34569A1) to separate drive shaft from pinion gear (Figure 2), then remove shaft and gear.

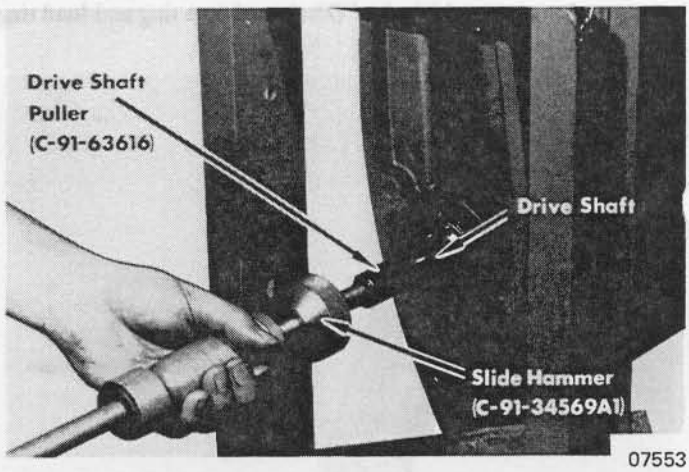

Figure 2. Removing Drive Shaft

CLEANING and INSPECTION

1. Clean all components in solvent and dry with compressed air.

CAUTION: DO NOT spin bearings with compressed air, as bearings may be damaged.

2. Inspect area of drive shaft where roller bearing rides. Pitting, grooves, scoring, uneven wear, discoloration from overheating and embedded foreign metal particles are all reasons for replacement of drive shaft and roller bearing.
3. Check drive shaft upper and lower tapered roller bearings by inspecting bearing cups. Replace bearings and bearing cups if cups are pitted, grooved, scored, worn uneven, discolored from overheating or have foreign metal particles embedded in cup.
4. Inspect drive shaft splines (both ends) for wear.
5. If propeller shaft was bent, check drive shaft for straightness.
6. Inspect drive (pinion) gear for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear if any of above exist.

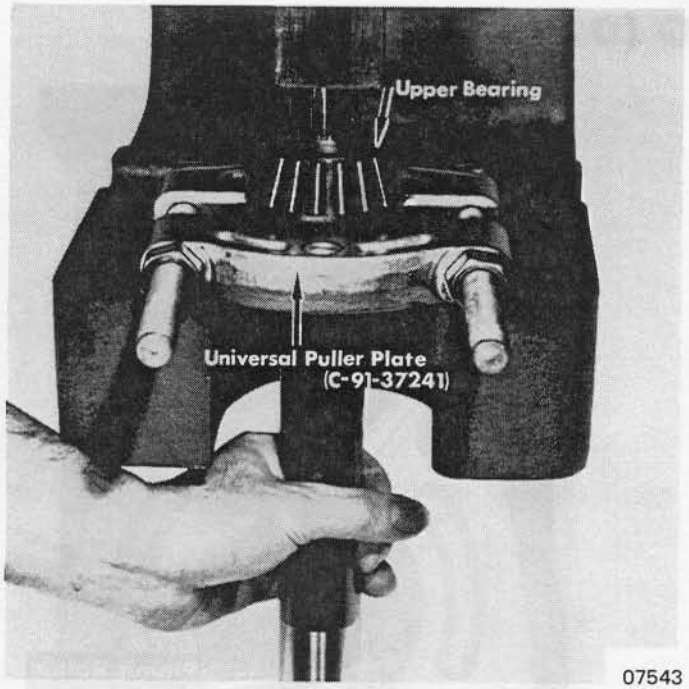

Figure 2. Pressing Upper Bearing from Shaft

DISASSEMBLY

1. Press upper bearing from drive shaft with Universal Puller Plate Tool (C-91-37241). (Figure 2)
2. Use Universal Puller Plate to press lower bearing from drive shaft. (Figure 3)

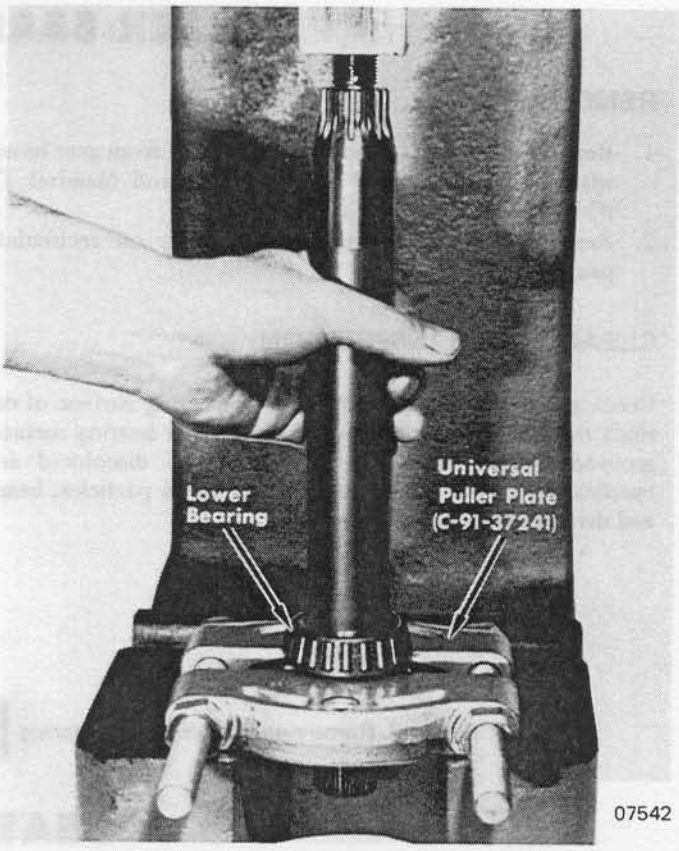

Figure 3. Pressing Lower Bearing from Shaft

TAPERED ROLLER BEARING CUP (DRIVE SHAFT and PROPELLER SHAFT)

REMOVAL

Using Slide Hammer Tool (C-91-34569A1), remove small drive shaft tapered roller bearing cup from gear housing (Figure 4) and remove shims. Using same procedure, remove propeller shaft tapered roller bearing cup from gear housing and remove shims.

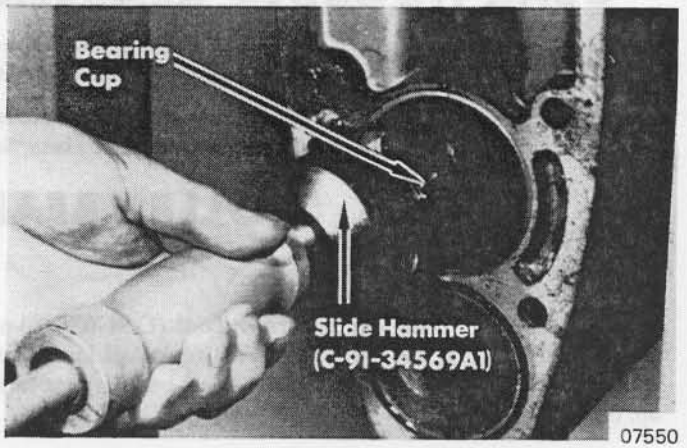

Figure 4. Remove Tapered Roller Bearing Cup

CLEANING and INSPECTION

Inspect bearing cups for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles and replace bearing cup and bearing if any of these exist.

ROLLER BEARING (DRIVE SHAFT)

REMOVAL

1. Remove drive shaft pinion roller bearing from gear housing with Driver Rod Tool (C-91-37323) and Mandrel Tool (C-91-55917). (Figure 5)
2. Remove "O" ring from gear housing oil recirculating passage.

CLEANING and INSPECTION

Check drive shaft roller bearing by inspecting surface of drive shaft on which bearing rides. If drive shaft bearing surface is grooved, scored, pitted, worn unevenly, discolored from overheating or has embedded foreign metal particles, bearing and drive shaft must be replaced.

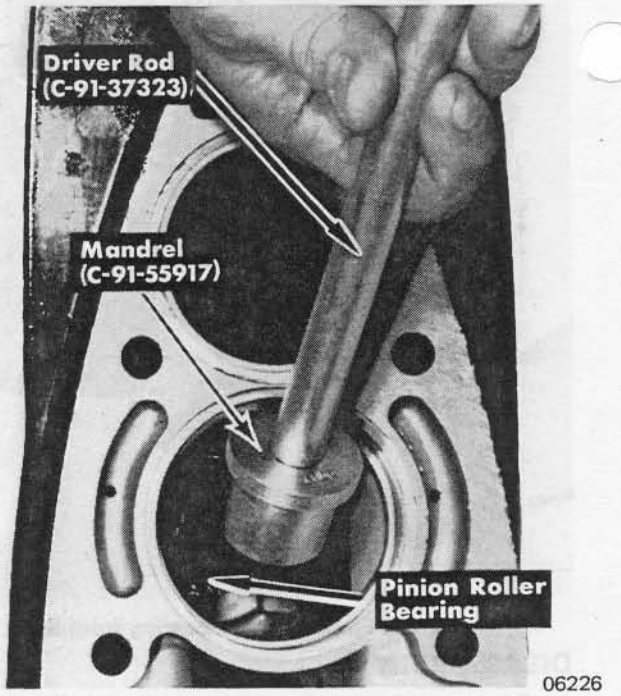

Figure 5. Removing Pinion Roller Bearing

GEAR HOUSING

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air.
2. Check gear housing carefully for impact damage.
3. Check for loose fitting bearing cups and needle bearings.

NOTE: Lower drive shaft (located in gear housing) upper bearing cup should be a loose fit in gear housing.

4. Inspect bearing carrier retainer threads in gear housing for corrosion or stripped threads.

GEAR HOUSING REASSEMBLY - RIGHT HAND ROTATION

NOTE: For left hand rotation, follow right hand rotation instructions, following, and refer to "Left Hand Rotation Variations" (see "Index").

IMPORTANT: Install same amount of shims that were removed. Follow "General Service Recommendations" (see "Index"). Refer to Figure B for parts identification.

ROLLER BEARING (DRIVE SHAFT)

INSTALLATION

Use Drive Shaft Pinion Bearing Driver Tool (C-91-63638) and Installing Tool (part of C-91-31229A4) to install lower drive shaft pinion bearing with numbered end of bearing case facing up. (Figure 1)

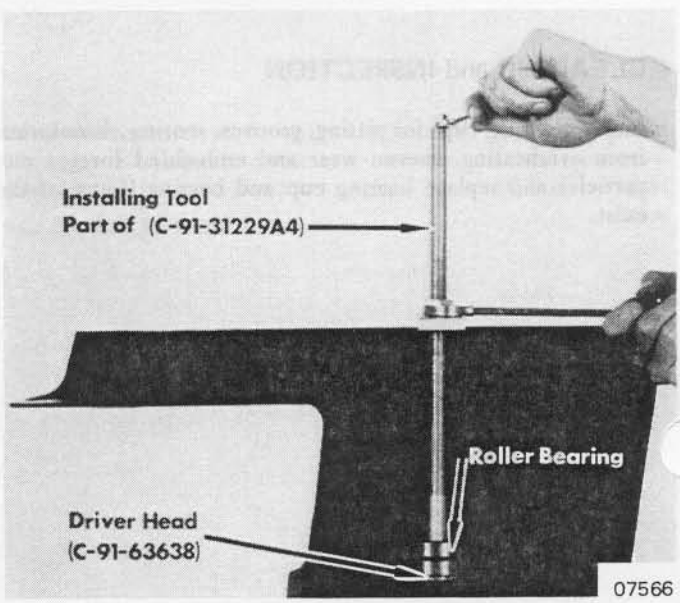

Figure 1. Installing Roller Bearing

TAPERED ROLLER BEARING CUP (DRIVE SHAFT and PROPELLER SHAFT)

INSTALLATION

1. Install shims and use Tool C-91-63619 to install small drive shaft bearing cup. (Figure 2)

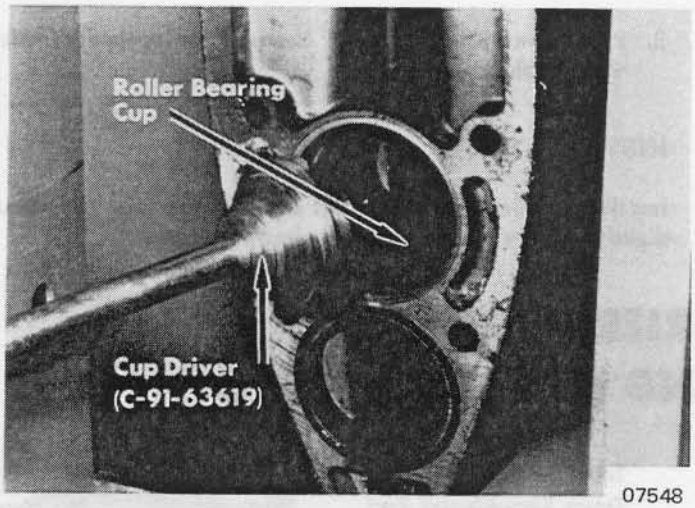

Figure 2. Installing Drive Shaft Bearing Cup

Figure 3. Installing Propeller Shaft Bearing Cup

2. Install shims and use Driver C-91-63626 to install front propeller shaft bearing cup. (Figure 3)

DRIVE SHAFT ASSEMBLY and PINION GEAR

REASSEMBLY

Press lower bearing and upper bearing onto drive shaft with suitable mandrels. (Figure 4)

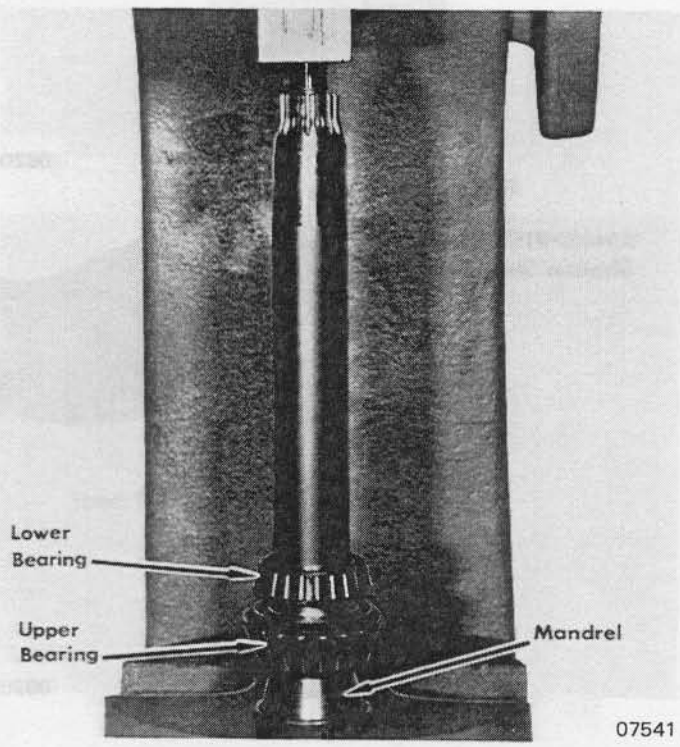

Figure 4. Pressing Upper Bearing on Shaft

INSTALLATION

NOTE: On left hand rotation gear housing, install driven gear before pinion gear and drive shaft.

1. Install drive shaft and bearing assembly into gear housing.
2. Install pinion gear, dished washer (concave side toward pinion gear) and pinion nut. Use Loctite Type "A" (C-92-32609-1) on pinion nut threads, if shimming is correct. Torque to specifications, using Drive Shaft Socket (C-91-63620A1).

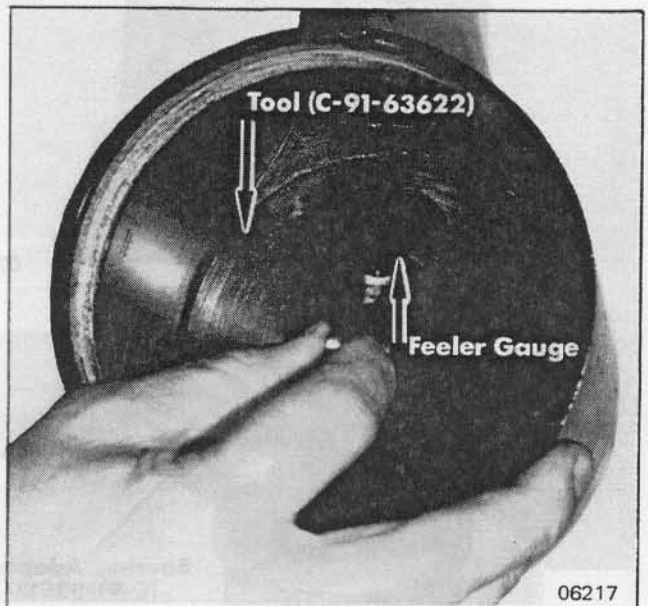

Figure 5. Checking Pinion Gear Shimming

SHIMMING (PINION GEAR)

a. Carefully place Shimming Tool (C-91-63622) in gear housing. (Figure 5) Push in on drive shaft to simulate bearing preload and rotate to seat bearing

rollers. Hold drive shaft in this position and measure clearance between tool and gear with a feeler gauge. Clearance must be .025.

b. If clearance is more or less than .025, remove drive shaft, pinion gear and drive shaft small bearing cup. Add or remove shims under bearing cup equal to the difference between .025 and your reading. Reinstall bearing cup, drive shaft and pinion gear. Use Loctite Type "A" (C-92-32609-1) on threads of nut. Recheck clearance.

PROPELLER SHAFT ASSEMBLY - RIGHT HAND ROTATION

REASSEMBLY

NOTE: For left hand rotation propeller shaft differences, refer to "Left Hand Rotation Variations" (see "Index").

1. Use a suitable mandrel and press driven gear bearing onto driven gear.
2. Align driven gear splines with propeller shaft splines and press gear on propeller shaft.
3. Press front propeller shaft bearing onto propeller shaft with suitable mandrel.

INSTALLATION

Install assembled propeller shaft into gear housing. Tilt shaft slightly to allow front bearing to clear pinion gear.

BEARING CARRIER ASSEMBLY ("O" RING, THRUST RING and LOAD RING)

REASSEMBLY

1. Install tapered roller bearing cup in bearing carrier with Driver Tool (C-91-63626). (Figure 6)

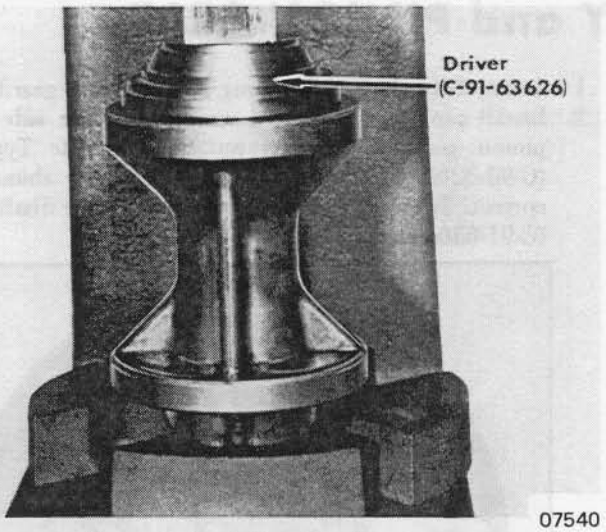

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Figure 6. Installing Bearing Cup

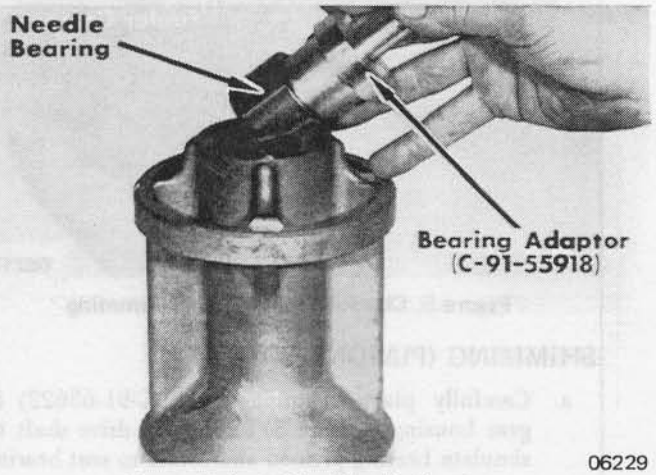

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Figure 7. Installing Needle Bearing

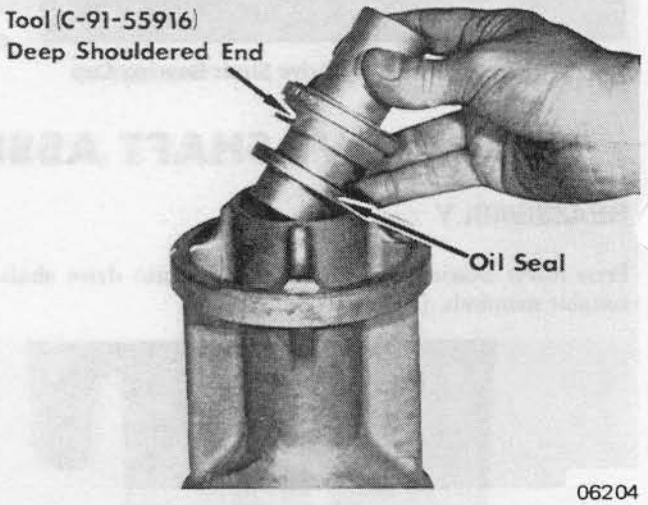

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Figure 8. Installing First Oil Seal

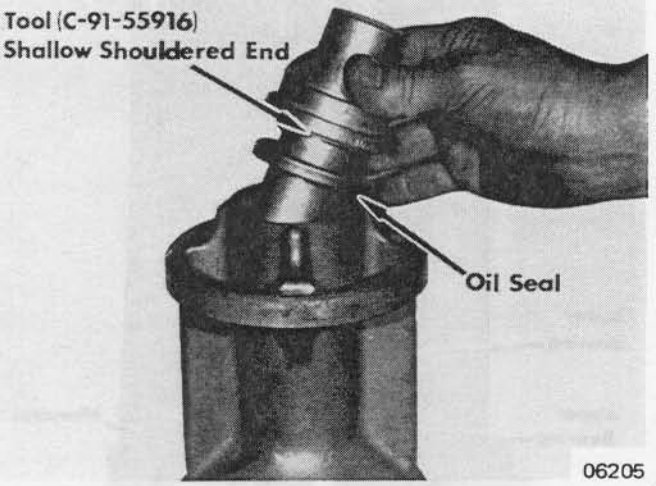

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Figure 9. Installing Second Oil Seal

2. Using Bearing Adaptor Tool (C-91-55918), install needle bearing in carrier. (Figure 7)
3. Use deep shouldered end of Driver Tool (C-91-55916) to install first oil seal with lip facing in. (Figure 8)

4. Use shallow shouldered end of Driver Tool (C-91-55916) to install second oil seal with lip facing out. (Figure 9)
5. Fill space between oil seals with Multipurpose Lubricant (C-92-63250).

INSTALLATION

NOTE: If gear housing has shims between bearing carrier thrust ring and gear housing shoulder instead of load ring, DO NOT continue with following instructions. Refer to MerCruiser Service Manual C-90-60673 which includes prior models.

1. Install bearing carrier assembly and carrier locating key into gear housing. DO NOT install propeller shaft load ring, thrust ring or "O" ring at this time.
2. Install threaded bearing carrier retainer WITHOUT tab washer. Torque retainer SLOWLY until sufficient amount of preload is obtained on propeller shaft bearings to check pinion gear backlash.

CAUTION: DO NOT over-torque retainer, or damage may occur to propeller shaft bearings.

3. Position dial indicator on machined surface of propeller shaft just behind bearing carrier. Push propeller shaft to one side and hold in this position while zeroing dial indicator. Move propeller shaft to opposite side. Shaft deflection should be max. .003" (.076mm). DO NOT turn propeller shaft. Repeat procedure, moving shaft up-and-down. If shaft deflection is more than .003", shaft and/or needle bearing is worn or propeller shaft is undersize.

SHIMMING (GEAR BACKLASH)

a. Use Dial Indicator and Indicator Rod (C-91-53459), position Mark II, to check gear backlash which should be .011" to .015" (.279 to .381mm). (Figure 10) Push in on drive shaft to simulate bearing preload and turn drive shaft and pinion gear back-and-forth. Use light turning pressure to prevent propeller shaft from turning. Dial indicator registers amount of gear backlash (clearance) between gear teeth.

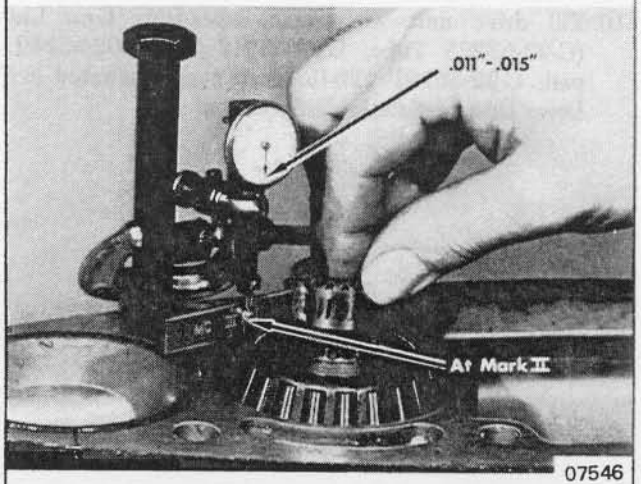


Figure 10. Checking Pinion Gear Backlash

b. Right Hand Rotation: If backlash is more than specified, remove shims from under propeller shaft front bearing cup. If backlash is less than specified, add shims under propeller shaft front bearing cup. Left Hand Rotation: If backlash is more than specified, add shims under propeller shaft front bearing cup. If backlash is less than specified, remove shims from under propeller shaft front bearing cup.

NOTE: If gear housing or any internal gear housing components have been changed, a NEW load ring must be installed.

4. Remove bearing carrier assembly and install load ring, thrust ring and "O" ring into gear housing.
5. Coat outer diameters of bearing carrier with Perfect Seal (C-92-34227) and fill space between oil seals with Multipurpose Lubricant (C-92-63250). Reinstall bearing carrier assembly and carrier locating key into gear housing.
6. Install tab washer. Coat threads of retainer with Perfect Seal and install retainer. Torque retainer SLOWLY (periodically checking propeller shaft bearing preload with inch-pound torque wrench, shown in Figure 11) until correct propeller shaft bearing preload is obtained. See "Specifications" Section 8.

IMPORTANT: DO NOT over-torque retainer to excessive bearing preloads. Over-torque will collapse load ring excessively and require load ring replacement.

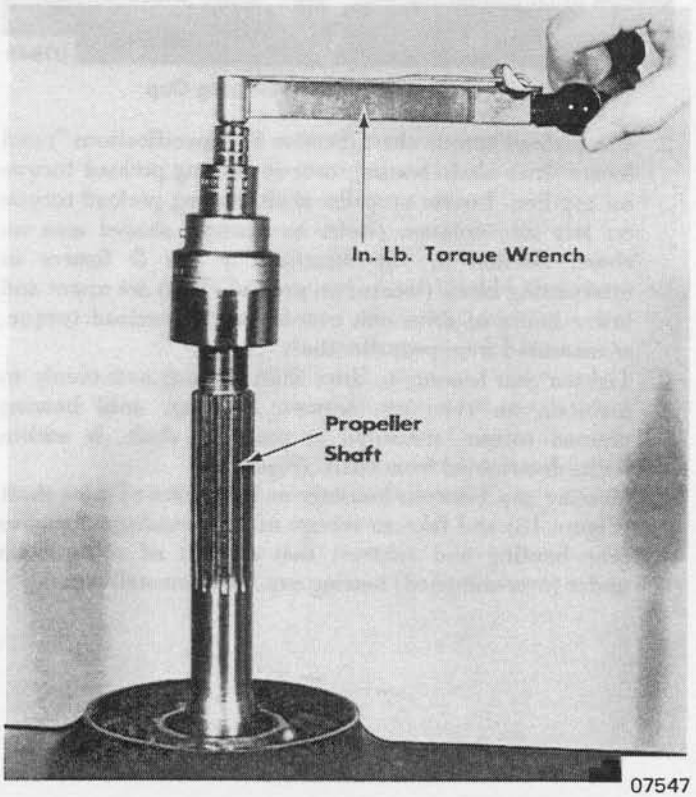


Figure 11. Checking Propeller Shaft Bearing Preload Torque

7. Bend one tab on bearing carrier retainer tab washer into slot provided on retainer.

NOTE: Make a note of propeller shaft bearing preload torque for future use in determining gear housing drive shaft bearing preload torque and drive unit over-all bearing preload torque. Adjust gear housing drive shaft bearing preload torque as illustrated in "Gear Housing Installation" (see Index).

GEAR HOUSING INSTALLATION

NOTE: If gear housing, drive shaft housing, lower drive shaft or lower drive shaft components HAVE NOT been replaced, start installation procedures at step No. 5.

1. Set preload on lower drive shaft tapered roller bearings by over-shimming (.060" [.152mm] or more) lower drive shaft bearing cup (located in drive shaft housing). (Figure 12) Connect gear housing to drive shaft housing with 7 nuts. Do not tighten nuts at this time.

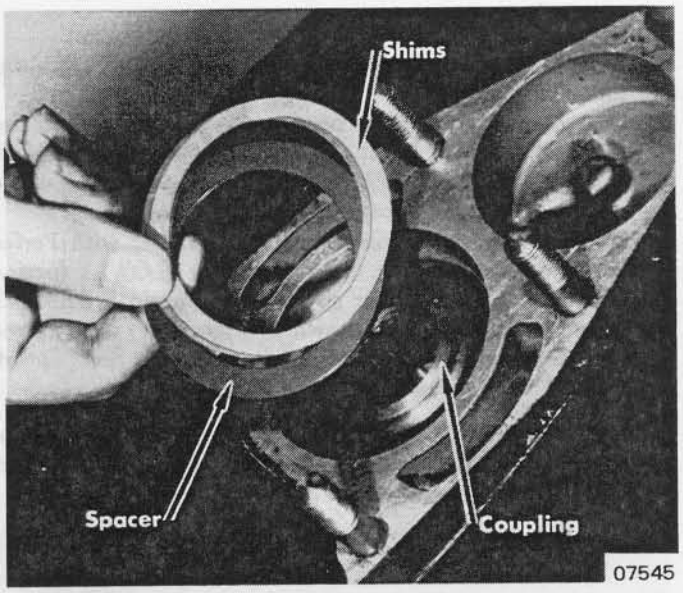


Figure 12. Over-Shimming Bearing Cup

2. Use preload torque chart (Section 8, "Specifications") and locate drive shaft housing over-all bearing preload torque on top line. Locate propeller shaft bearing preload torque on left side column. (Refer to example shaded area on chart, Section 8, "Specifications".) The 2 figures in intersecting block (located on preload chart) are upper and lower limits of drive unit over-all bearing preload torque, as measured from propeller shaft.
3. Tighten gear housing to drive shaft housing nuts evenly to maintain an even gap between housings until bearing preload torque, measured at propeller shaft, is within limits determined from chart. (Figure 13)
4. Measure gap between housings on both sides of drive shaft (Figure 13) and take an average of these readings. Remove gear housing and subtract that amount of shims from under (over-shimmed) bearing cup, then reinstall cup.
5. Install trim tab allen head screw (if removed) in hole provided in gear housing.
6. Install "O" ring around lower drive shaft bearing cup on drive shaft housing and "O" ring in groove around oil recirculating passage in gear housing.
7. Connect gear housing to drive shaft housing with 7 nuts. Tighten evenly. Recheck overall preload.
8. Install one allen head screw (located in trim tab cavity).
9. Install trim tab and trim tab screw access hole plug. Replace propeller and propeller components.

Figure 13. Installing Gear Housing

CAUTION: Propeller nut must be locked with tab washer to retain propeller.

10. Fill drive unit with fresh Super-Duty Gear Lubricant (C-92-63225 Tube, C-92-63242 Can, C-92-65149 35-lb. pail, C-92-56101 120-lb. drum), as illustrated in "Stern Drive Unit Installation", Section 2.

DRIVE SHAFT HOUSING ASSEMBLY

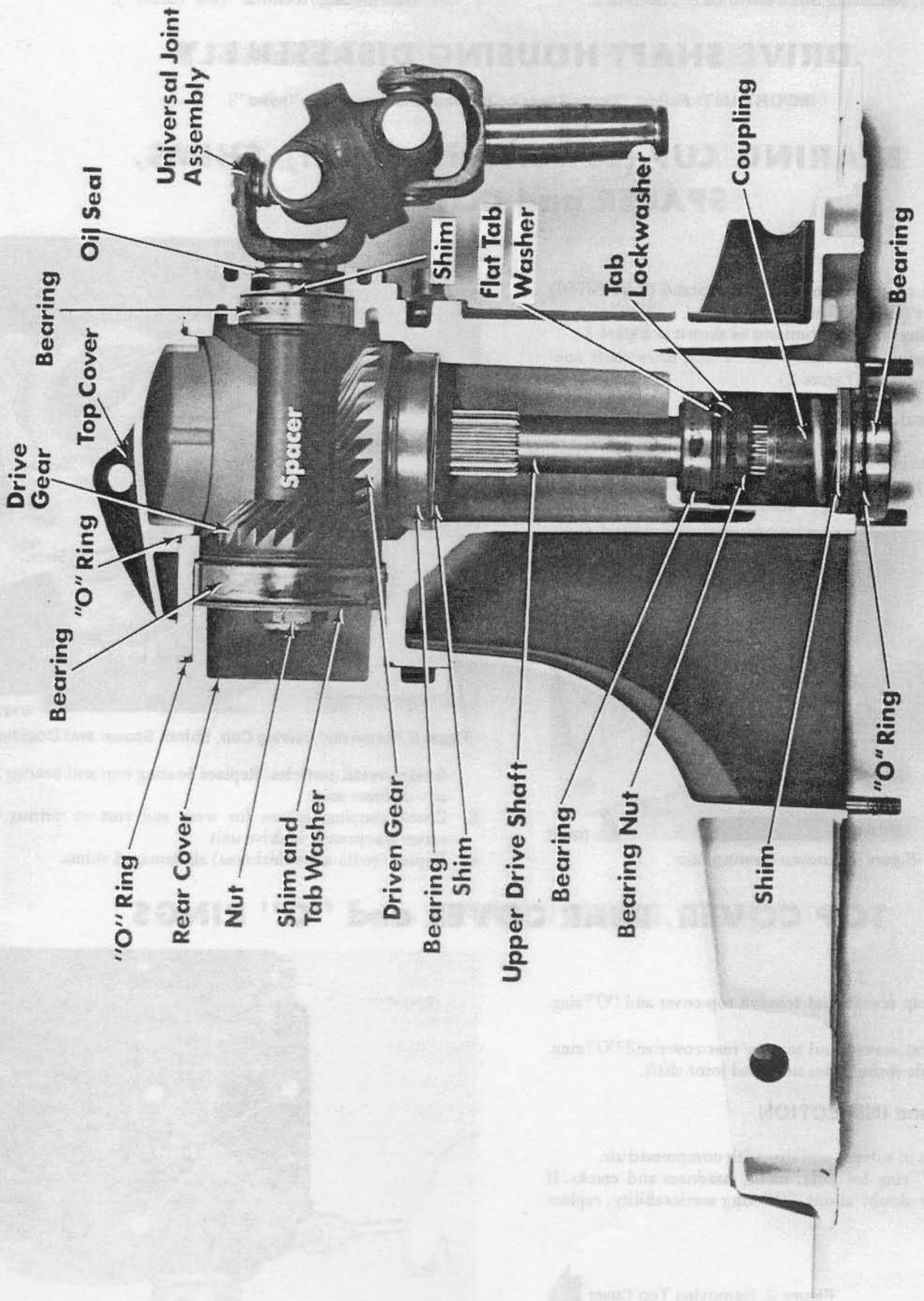


Figure A. Drive Shaft Housing Parts Identification

DRIVE SHAFT HOUSING REMOVAL

1. Remove drive unit from transom as illustrated in "MerCruiser II-TR, Removing Stern Drive Unit", Section 2.
2. Separate gear housing from drive shaft housing as outlined in "Gear Housing Removal" (see "Index").

DRIVE SHAFT HOUSING DISASSEMBLY

IMPORTANT: Follow "General Service Recommendations" (see "Index").

BEARING CUP (Lower Drive Shaft), SHIMS, SPACER and COUPLING

REMOVAL

1. Mount drive shaft housing in Repair Stand (C-91-33750) with Adaptor (C-91-60524A1).
2. Loosen bearing cup from housing as shown in Figure 1.
3. Remove bearing cup, shims, spacer and drive shaft coupling from housing. (Figure 2)

CLEANING and INSPECTION

1. Clean all parts in solvent and dry with compressed air.
2. Inspect bearing cup for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cup and bearing, if any of these exist.
3. Check coupling splines for wear and rust or pitting, if water was present in drive unit.
4. Replace (with same thickness) all damaged shims.

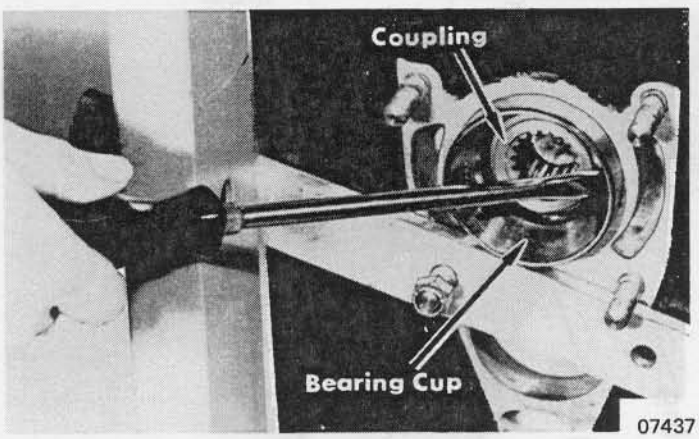


Figure 1. Loosen Bearing Cup

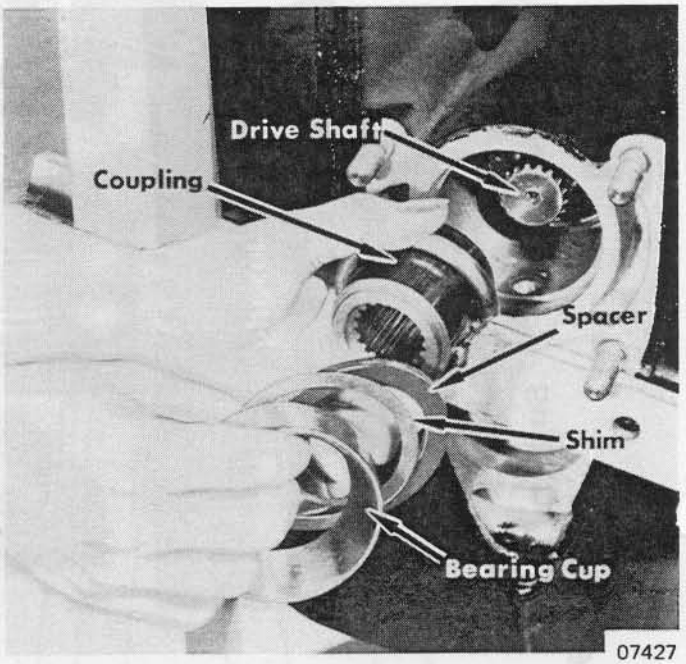


Figure 2. Removing Bearing Cup, Shims, Spacer and Coupling

TOP COVER, REAR COVER and "O" RINGS

REMOVAL

1. Remove 4 cap screws and remove top cover and "O" ring. (Figure 3)
2. Remove 4 cap screws and remove rear cover and "O" ring. Remove guide spring from universal joint shaft.

CLEANING and INSPECTION

1. Clean covers in solvent and dry with compressed air.
2. Inspect "O" ring for cuts, nicks, hardness and cracks. If there is any doubt about "O" ring serviceability, replace "O" ring.

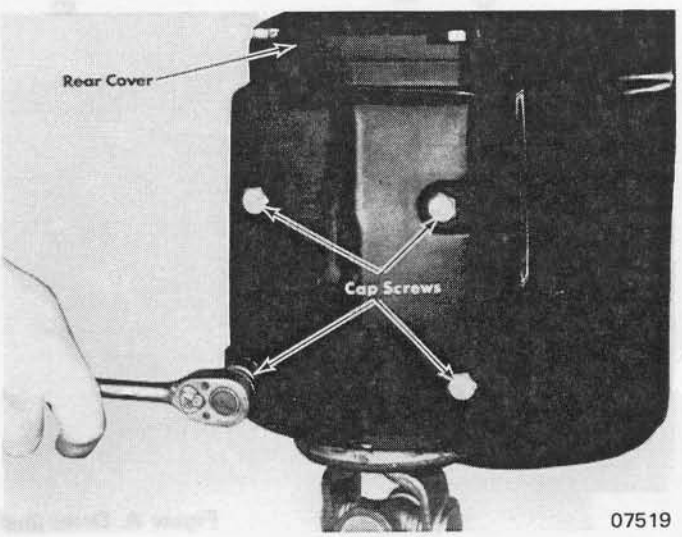


Figure 3. Removing Top Cover

UNIVERSAL JOINT

REMOVAL

Install Bearing Holder Tool (C-91-63625) in place of rear cover. (DO NOT over-tighten cap screws.) Loosen universal joint shaft nut as shown in Figure 4. Remove nut and universal joint assembly. (Figure 5)

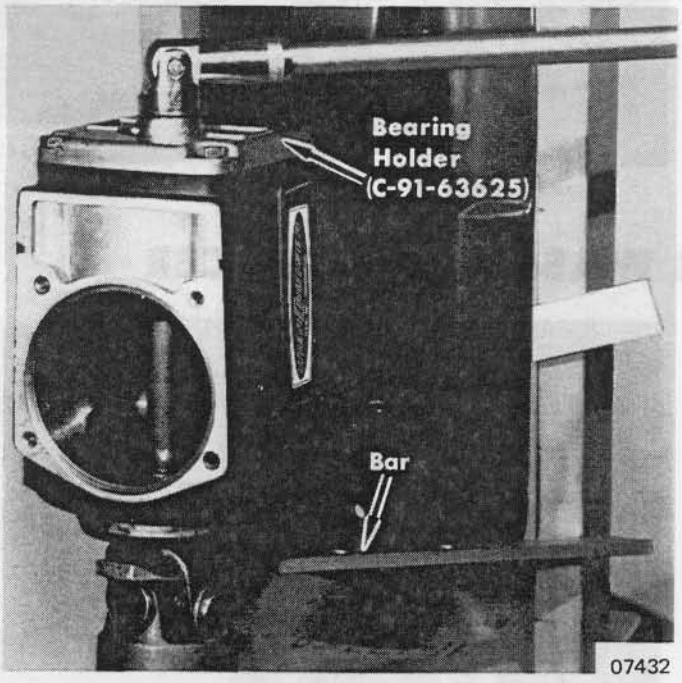


Figure 4. Loosening Universal Joint Nut

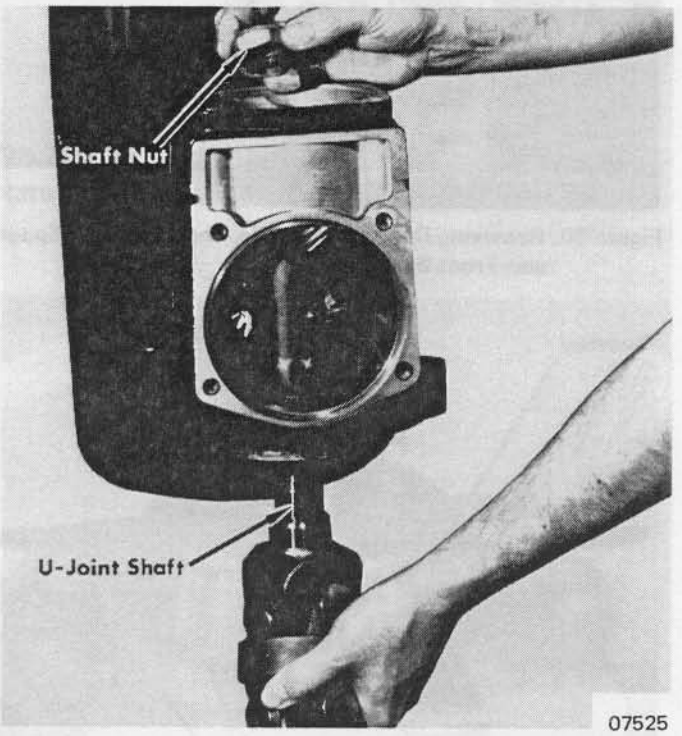


Figure 5. Removing Universal Joint Shaft

CLEANING and INSPECTION

1. Inspect splines on both coupling and gear end of universal joint assembly for wear.
2. Clean all corrosion from coupling end. If splines are partially corroded away, replace coupling end yoke.

   NOTE: If universal joint coupling end splines are corroded or worn, also inspect transmission coupling splines. Lubricate universal joint spline and engine coupling splines with Multipurpose Lubricant (C-92-63250) before drive unit installation.

3. Inspect shaft (between yoke and splines) on gear end of universal joint for groove where oil seal rides. If grooved, install NEW oil seal to ride on shaft in new location, using Tool C-91-63619. Refer to "Drive Shaft Housing Reassembly" subhead "Oil Seal (Universal Joint)" (see "Index").
4. Check bearings for excessive looseness, tightness, roughness and worn or pitted surface from presence of water in bellows. Replace cross and bearing assemblies, if these exist.

IMPORTANT: Use only Universal Joint Lubricant (C-92-58229) for lubricating universal joint bearings.

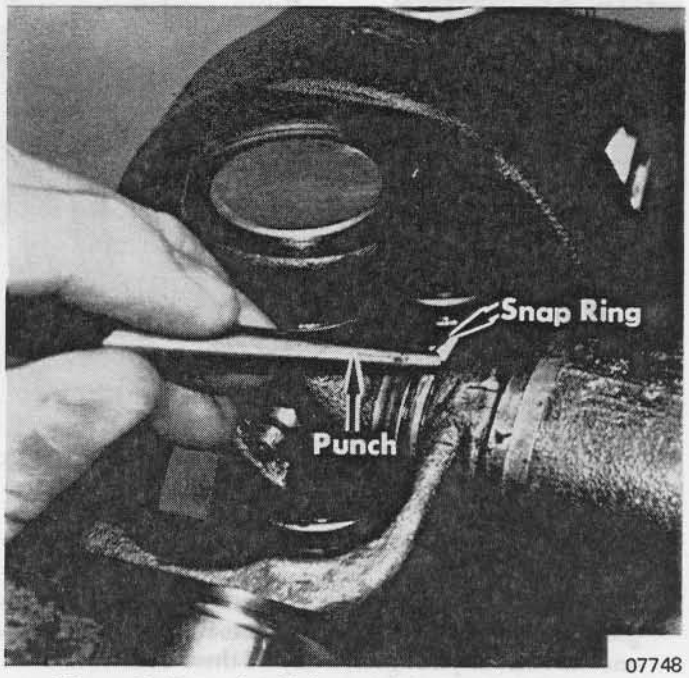


Figure 6. Removing Universal Joint Bearing Snap Rings

DISASSEMBLY

1. Using a punch and hammer, drive off universal joint bearing snap rings. (Figure 6)
2. With suitable adaptor to support universal joint yoke, press on one bearing until opposite bearing is pressed into adaptor. Remove loose bearing. (Figure 7)

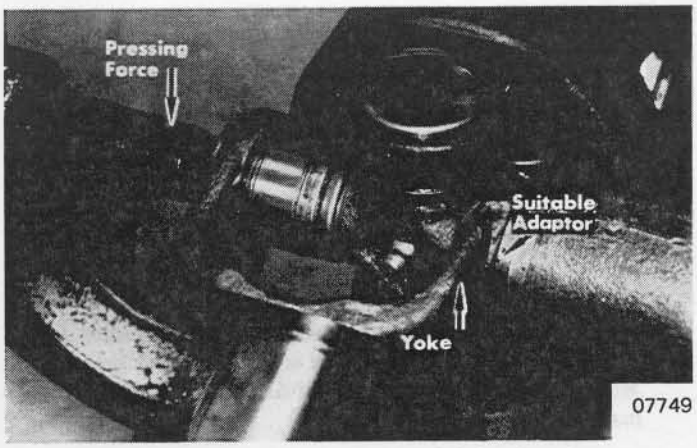


Figure 7. Removing First Universal Joint Bearing

3. Turn universal joint assembly 180° and press on bearing cross-member to remove second bearing. (Figure 8) Remove each pair of bearings in this manner.

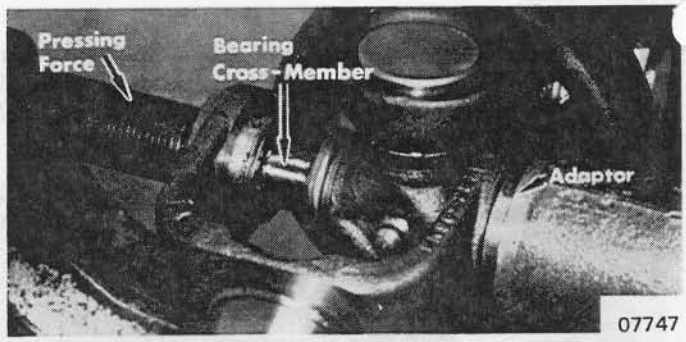


Figure 8. Removing Second Universal Joint Bearing

DRIVE GEAR, SHIMS, TAB WASHER and SPACER

REMOVAL

1. Remove washer, shims and tab washer. (Figure 9)
2. Remove drive gear and bearing assembly and remove spacer and front bearing. (Figure 10)

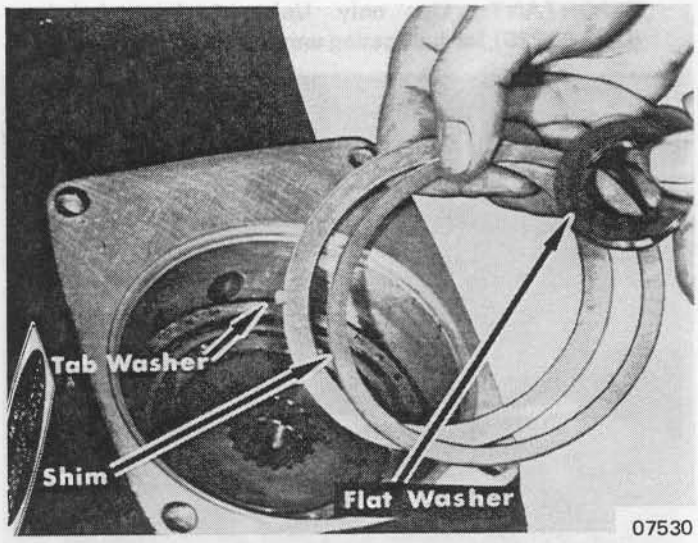


Figure 9. Removing Washer, Shims and Tab Washer

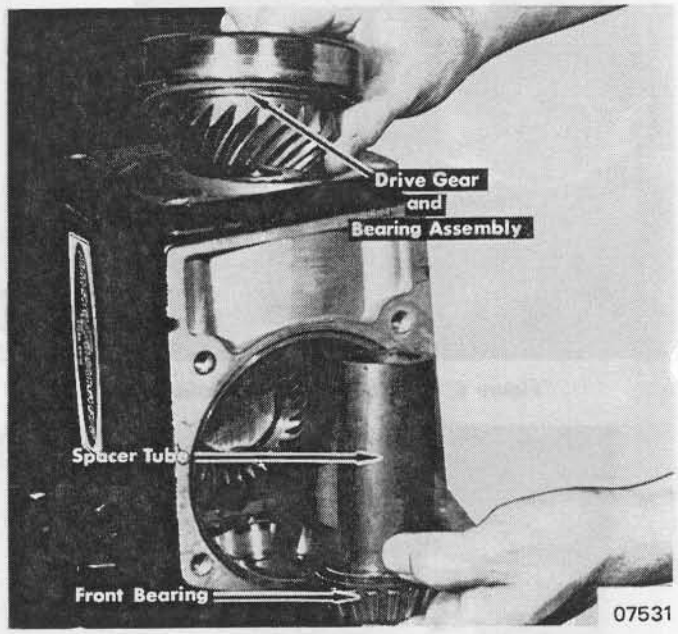


Figure 10. Removing Drive Gear and Bearing Assembly, Spacer and Front Bearing

CLEANING and INSPECTION

1. Clean in solvent and dry with compressed air. Inspect drive gear for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear, if any of these exist.
2. Replace (with same thickness) all damaged shims.
3. Check bearing cups for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cups and bearings, if any of these exist.

DISASSEMBLY

Using Universal Puller Plate Tool (C-91-37241) and suitable mandrel, press drive gear from bearing. (Figure 11)

NOTE: Remove bearing only if replacement is necessary. Bearing is damaged beyond repair during removal.

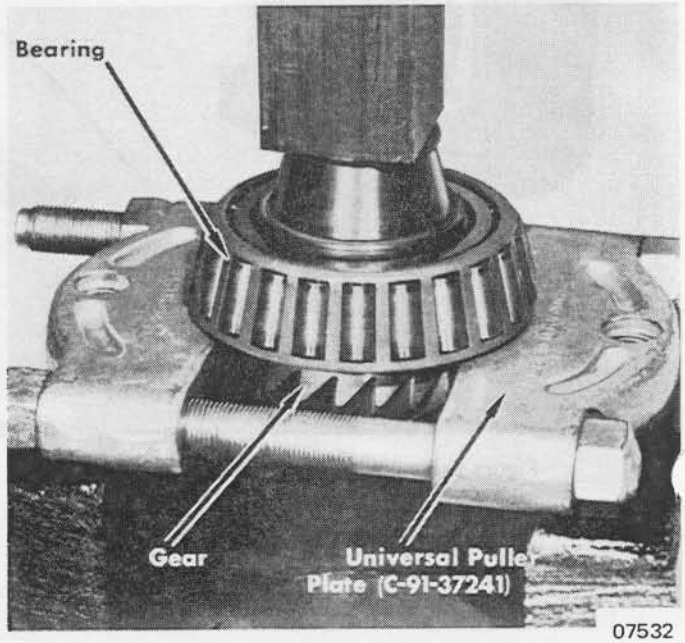


Figure 11. Pressing Gear from Bearing

BEARING CUP, OIL SEAL (UNIVERSAL JOINT) and "O" RING

REMOVAL

1. Using Slide Hammer Tool (C-91-34569A1), remove universal joint front bearing cup. (Figure 12) Remove shims.

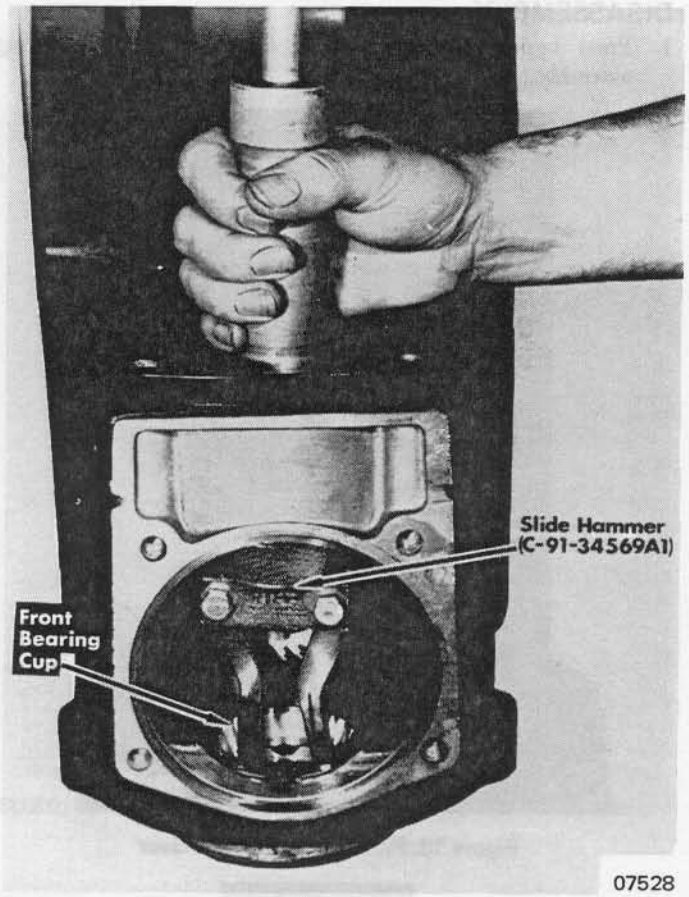


Figure 12. Removing Universal Joint Front Bearing Cup

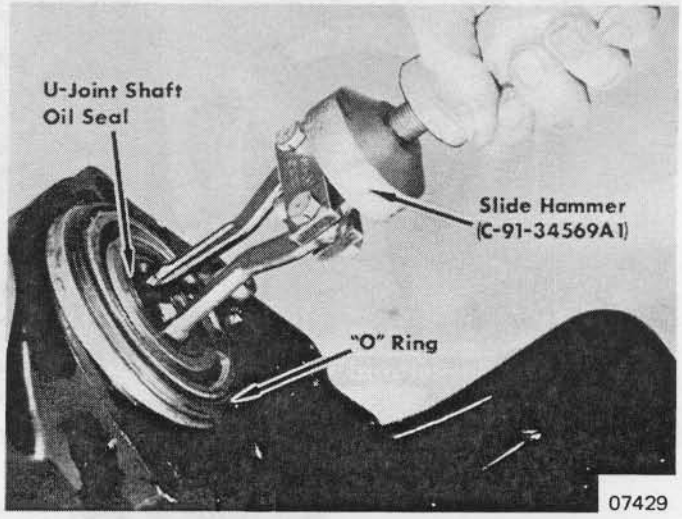


Figure 13. Removing Universal Joint Shaft Oil Seal

2. Remove universal joint shaft oil seal with Slide Hammer Tool. (Figure 13) Remove "O" ring from drive shaft housing pilot.

CLEANING and INSPECTION

1. Clean all metal parts in solvent and dry with compressed air.
2. Inspect bearing cup for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cup and bearing, if any of these exist.
3. Wipe oil seal and "O" ring with clean rag.
4. Inspect oil seal for wear, tears, roughness and proper spring position.

   NOTE: If there is a doubt about oil seal or "O" ring serviceability, replace them.

3. Inspect "O" ring for cuts, nicks, hardness and cracks.

DRIVE SHAFT, DRIVEN GEAR, BEARINGS and CHECK VALVE

REMOVAL

1. Bend tab washer from upper drive shaft bearing nut. (Figure 14)
2. Using Bearing Nut Wrench (C-91-63620) and Drive Shaft Socket (C-91-63621), loosen upper drive shaft bearing nut. (Figure 15) Turn drive shaft clockwise to loosen nut.
3. Remove nut, tab washer, flat tabbed washer and bearing from bottom of drive shaft housing. Remove driven gear and upper drive shaft assembly from top of drive shaft housing. (Figure 16)
4. Remove driven gear bearing cup and shims with Slide Hammer Tool (C-91-34569A1). (Figure 17)
5. Using Slide Hammer, remove bottom bearing cup. Refer to Figure 17, as procedure is similar.
6. Remove 3 screws, check valve cover, check valve, spring and gasket.
7. Remove quad (sealing) ring from check valve plunger.

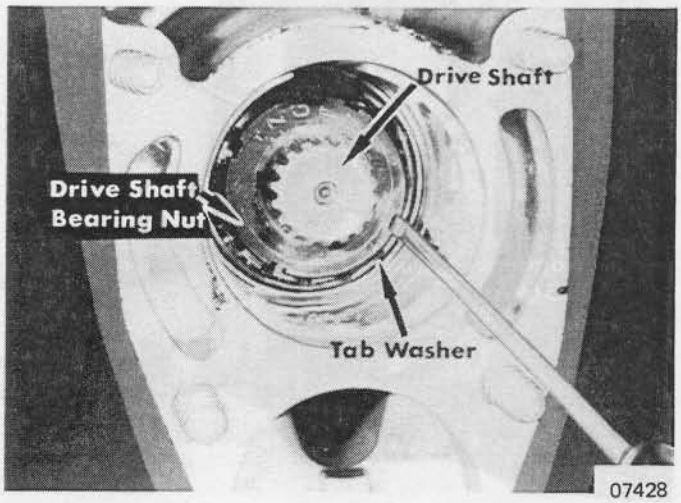


Figure 14. Bending Tab

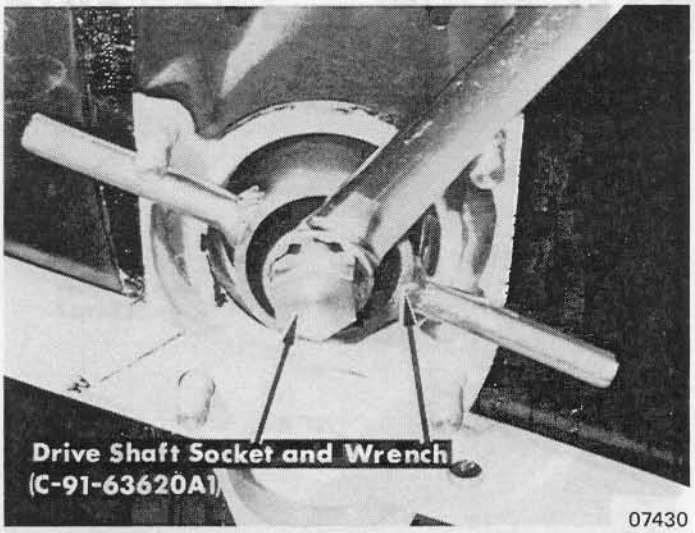


Figure 15. Loosening Bearing Nut

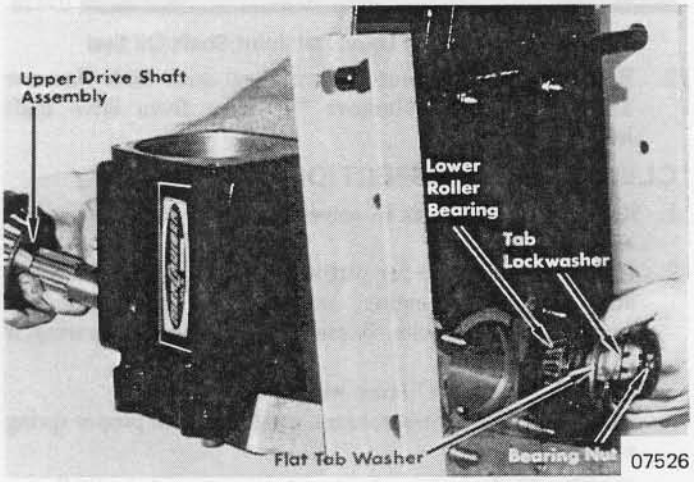


Figure 16. Removing Drive Shaft Assembly and Components

CLEANING and INSPECTION

1. Clean all parts in solvent and dry with compressed air.
2. Inspect driven gear for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear, if any of these exist.
3. Check bearing cups for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cups and bearings, if any of these exist.
4. Drive shaft splines should be checked for wear.

Figure 17. Removing Driven Gear Bearing Cup

DISASSEMBLY

1. Press upper drive shaft from driven gear and bearing assembly. (Figure 18)

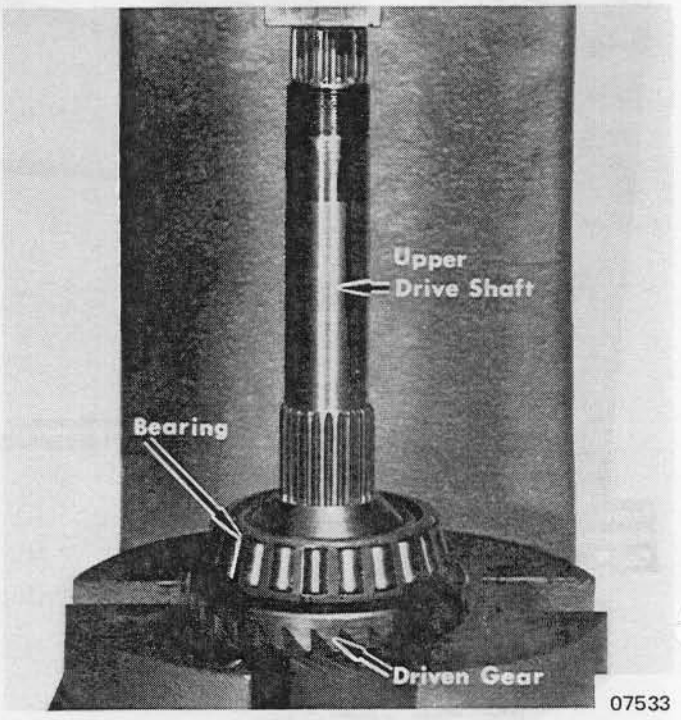


Figure 18. Pressing Shaft from Gear

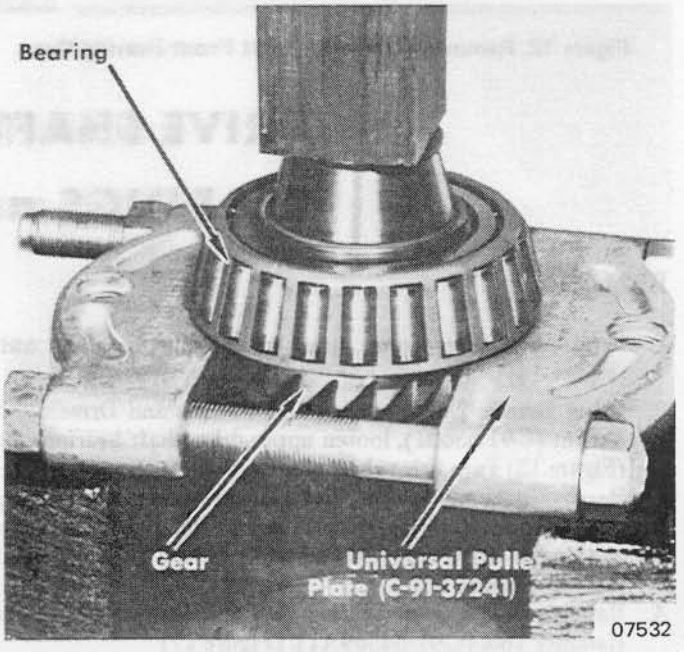


Figure 19. Pressing Gear from Bearing

2. Using Universal Puller Plate Tool (C-91-37241) and suitable mandrel, press driven gear from bearing. (Figure 19)

NOTE: Remove bearing only if replacement is necessary. Bearing is damaged beyond repair during removal.

DRIVE SHAFT HOUSING

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air.
2. Check housing carefully for impact damage.
3. Check for loose fitting bearing cups.

DRIVE SHAFT HOUSING REASSEMBLY

IMPORTANT: Follow "General Service Recommendations" (see "Index"). Install same amount of shims that were removed.

BEARING CUP (for Driven Gear and Drive Shaft)

INSTALLATION

1. Install driven gear bearing shims. Use Bearing Cup Driver Tool (C-91-63626) and install driven gear bearing cup. (Figure 1)
2. Install upper drive shaft bearing cup, as in Step 1, with Cup Driver (C-91-63619).

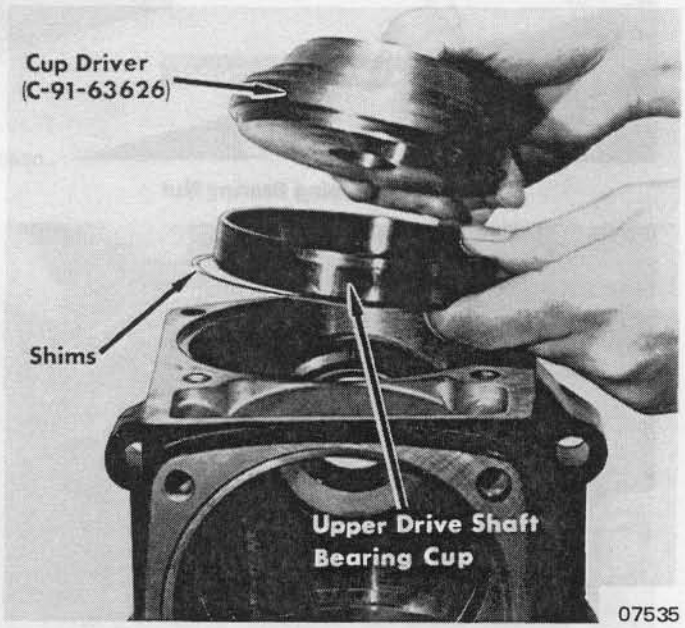


Figure 1. Installing Driven Gear Bearing Cup

DRIVE SHAFT and DRIVEN GEAR ASSEMBLY

REASSEMBLY

1. Press bearing onto driven gear with suitable mandrel.
2. Press upper drive shaft into driven gear and bearing assembly.

INSTALLATION

1. Install assembled upper drive shaft into top of housing. Install drive shaft tapered roller bearing, flat tabbed washer, new tab washer (align tabs on inside diameter of both washers with slot in drive shaft) and bearing nut (chamfered side of nut toward bearing) into bottom of drive shaft housing. (Figure 2)
2. Using Drive Shaft Socket and Wrench (C-91-63620A1), turn drive shaft counterclockwise and tighten nut (Figure 3) a sufficient amount to obtain specified preload (see "Specifications") on upper drive shaft bearings. Check preload as illustrated in Figure 4.

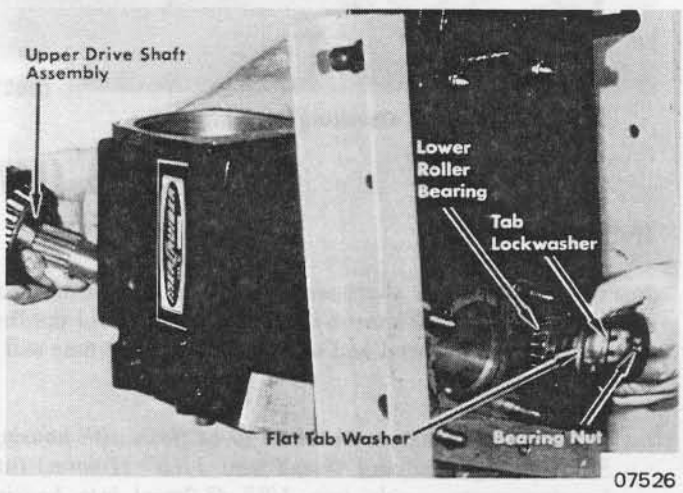


Figure 2. Installing Drive Shaft Assembly and Components

NOTE: Make a note of bearing preload torque for future use in determining universal joint shaft bearing preload torque.

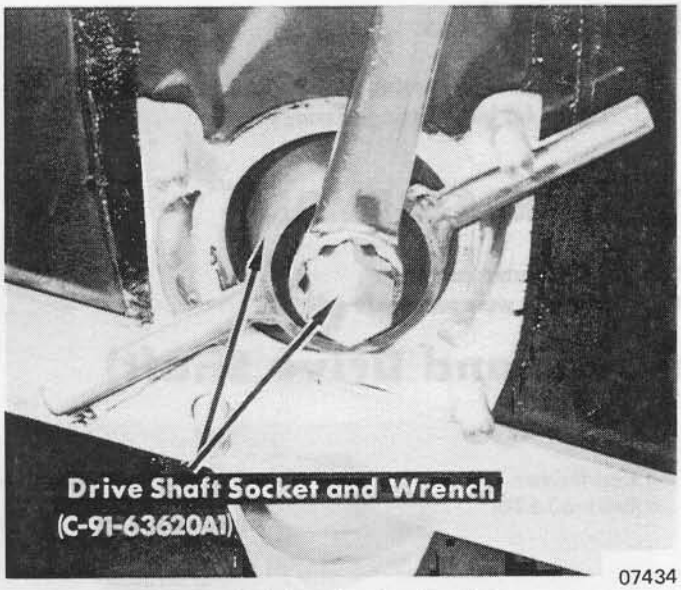


Figure 3. Tightening Bearing Nut

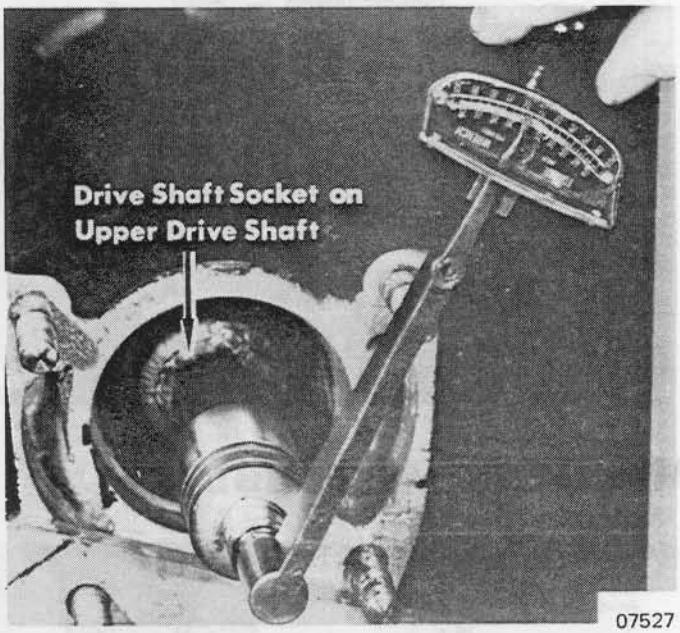


Figure 4. Checking Preload Torque

SHIMMING (DRIVEN GEAR)

a. Insert Shimming Tool (C-91-63623) into drive shaft housing with hole marked "MCIITR" toward driven gear.

> **CAUTION: Tool may be damaged if installed improperly.**

b. Use feeler gauge to measure gap (.025" [.635mm]) between driven gear and shimming tool. (Figure 5) If feeler gauge reading is too low, remove shims from under driven gear bearing cup. If reading is too high, add shims under bearing cup.

NOTE: If driven gear bearing cup shims are increased or decreased, upper drive shaft bearings preload torque must be readjusted (as in Step 2, preceding).

Figure 5. Checking Driven Gear Shimming

3. Align slot on upper drive shaft bearing nut with tab on tab washer and bend tab into slot.

OIL SEAL (UNIVERSAL JOINT)

INSTALLATION

Install universal joint shaft seal in housing with Installation Tool (C-91-63619). (Figure 6) Use side one of tool the first time that seal is replaced and side two the second time seal is replaced.

NOTE: Seal is factory-installed to be flush with housing. Side one of tool will install seal 1/16" (1.6mm) into housing cavity - side two 1/8" (3.2mm) into housing cavity. If universal joint shaft has been replaced, oil seal again should be installed flush with housing.

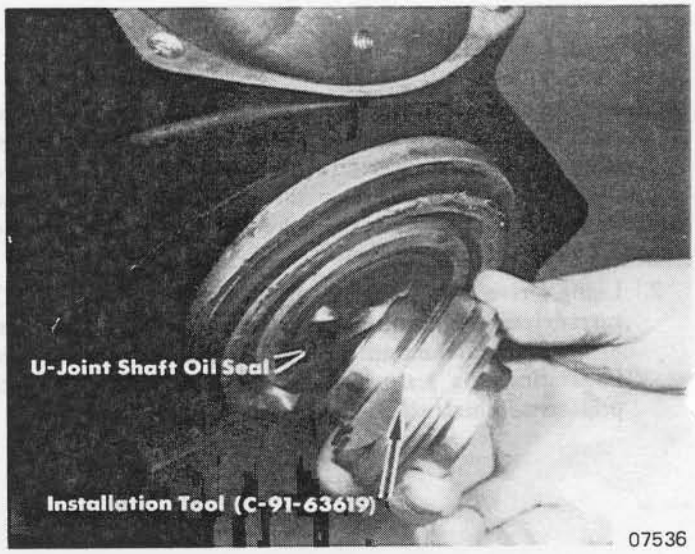


Figure 6. Installing Universal Joint Shaft Oil Seal

BEARING CUP (Universal Joint Front Bearing)

INSTALLATION

Install shims into drive shaft housing. Using flat side of Installation Tool (C-91-63619) toward gear (to allow clearance between driven gear and tool), install universal joint shaft tapered roller bearing cup. (Figure 7)

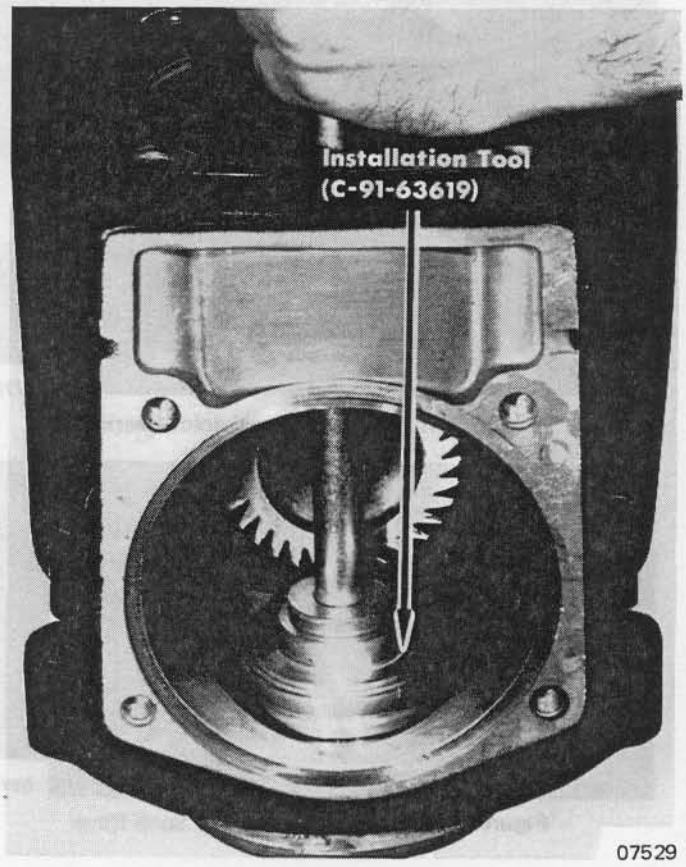


Figure 7. Installing Bearing Cup

DRIVE GEAR ASSEMBLY

REASSEMBLY

Press bearing onto drive gear with suitable mandrel.

INSTALLATION

Install bearing, spacer and drive gear and bearing assembly in housing. (Figure 8)

Figure 8. Installing Bearing, Spacer and Gear and Bearing Assembly

UNIVERSAL JOINT

REASSEMBLY

IMPORTANT: Use only Universal Joint Lubricant (C-92-58229) for lubricating universal joint bearings.

1. Place universal joint bearing caps in yoke and start them on bearing cross-members. Finish installation by pressing bearings through yoke and onto cross-members. (Figure 9)
2. Install bearing cap retaining snap rings. (Figure 10)

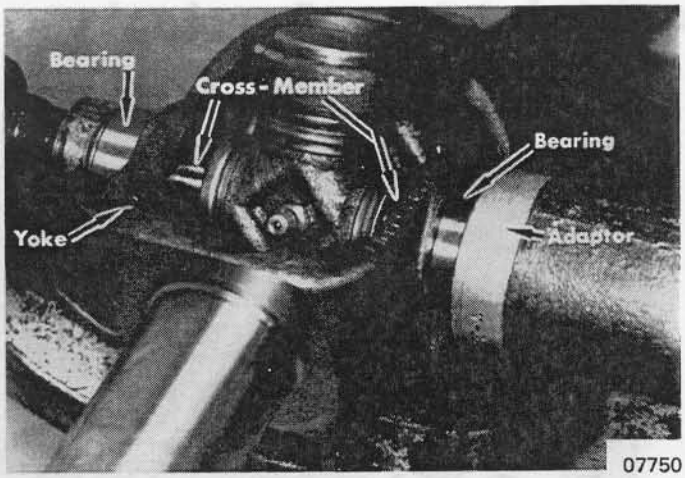


Figure 9. Installing Universal Joint Bearings

Figure 10. Installing Bearing Cap Snap Rings

INSTALLATION

1. Install tab washer next to bearing cup, with tab in oil hole, and install shims and universal joint shaft washer. (Figure 11)

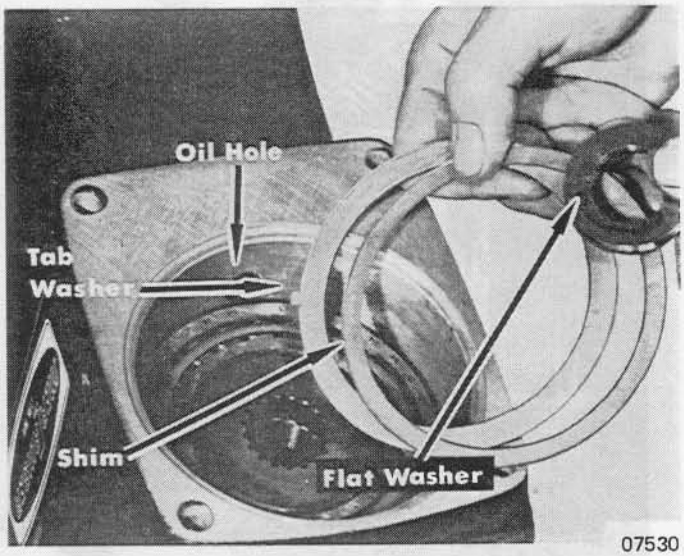


Figure 11. Installing Washers and Shims

2. Install universal joint shaft through front bearing, spacer and drive gear. Install nut on shaft. (Figure 12)
3. Install Bearing Holder Tool (C-91-63625) and torque universal joint shaft nut to specifications. (Figure 13)
4. Install rear cover "O" ring onto rear cover, then rear cover with 4 cap screws. Torque screws to specifications.
5. Check drive shaft housing over-all bearing preload torque at upper drive shaft. (Figure 4) Preload should be 5 to 11 in. lbs. (.887 to 1.95kg/cm) above preload, measured in "Drive Shaft and Driven Gear Assembly", subhead "Installation". Refer to "Index". Add shims under rear cover to increase preload and remove shims to decrease preload

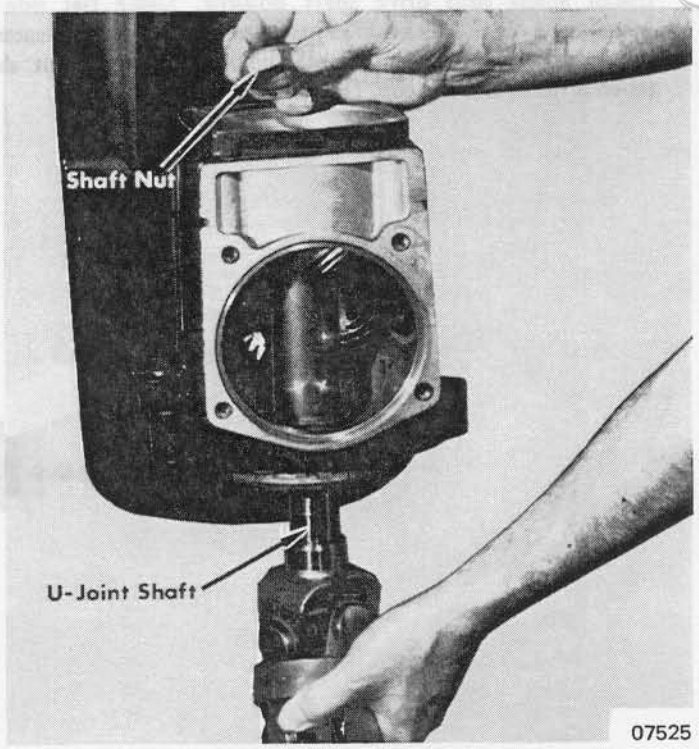


Figure 12. Installing Universal Joint

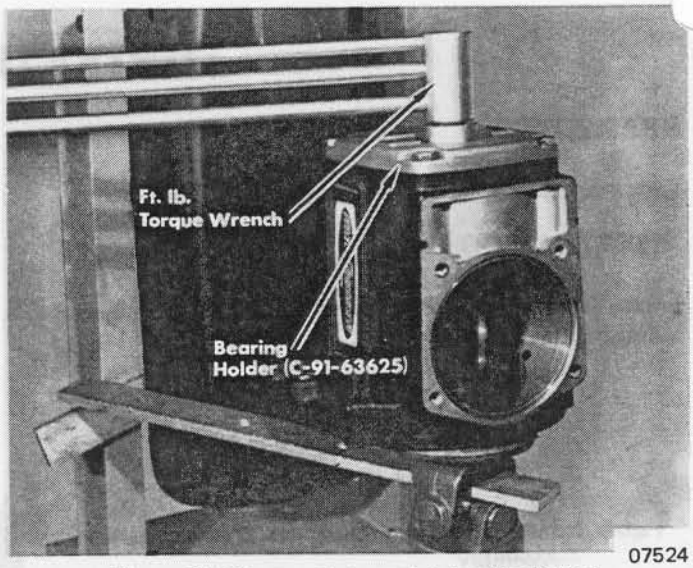


Figure 13. Torque Universal Joint Shaft Nut

SHIMMING (DRIVE GEAR)

Install Shimming Tool (C-91-63624) into drive shaft housing. Use feeler gauge to measure gap (.025" [.635mm]) between drive gear and shimming tool. (Figure 14) If feeler gauge reading is too low, add shims under universal joint shaft front bearing cup and remove same amount of shims from under rear cover. If reading is too high, remove shims from under front bearing cup and add shims in same amount under rear cover.

Figure 14. Measuring Drive Gear Shimming

6. Install "O" ring on top cover. Install top cover with 4 cap screws. Torque to specifications.
7. Install drive shaft coupler, spacer, shims and bearing cup. (Figure 15) Seat bearing cup in drive shaft housing with mallet.
8. Install quad (sealing) ring on check valve plunger and install spring, check valve, gasket and cover with 3 screws. Torque to specifications.

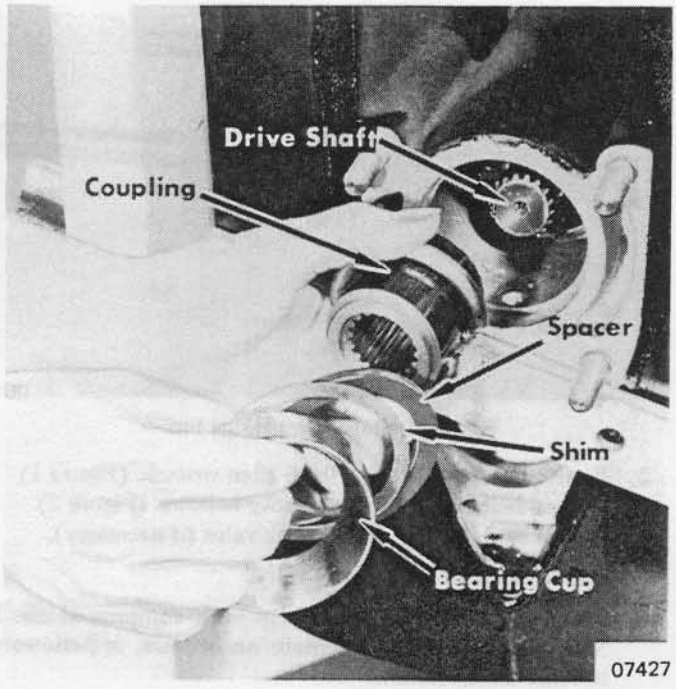


Figure 15. Installing Bearing Cup, Shims, Spacer and Coupling

9. Install new "O" ring on drive shaft housing pilot with Bellows Adhesive (C-92-36340).

NOTE: If gear housing, drive shaft housing, lower drive shaft or lower drive shaft components have been replaced, lower drive shaft bearing preload must be adjusted. Overshim bearing cup .060" (1.524mm) or more and refer to "Gear Housing Installation" (see "Index").

10. Install gear housing as outlined in "Gear Housing Installation" (see "Index").

DRIVE SHAFT HOUSING INSTALLATION

1. Install gear housing as outlined in "Gear Housing Installation" (see "Index").

NOTE: Engine alignment must be checked before installing drive unit. Refer to "II-TR Engine Alignment", Section 2.

2. Install drive unit as outlined in "II-TR, Stern Drive Installation", Section 2.

GIMBAL HOUSING DISASSEMBLY

REMOVAL from BOAT

Remove gimbal housing and transom plate from boat by referring to - "Removal, Installation and Alignment", Section 2.

NOTE: Remove oil hose at bell housing to drain gear lubricant from reservoir or, when changing bellows or bell housing, plug oil hose to retain gear lubricant in reservoir.

BELL HOUSING

REMOVAL

1. Remove trim limit switch and trim position sender assemblies from gimbal ring.

NOTE: Refer to Section 7, "Trim System", for electrical checks on limit switch and trim sender.

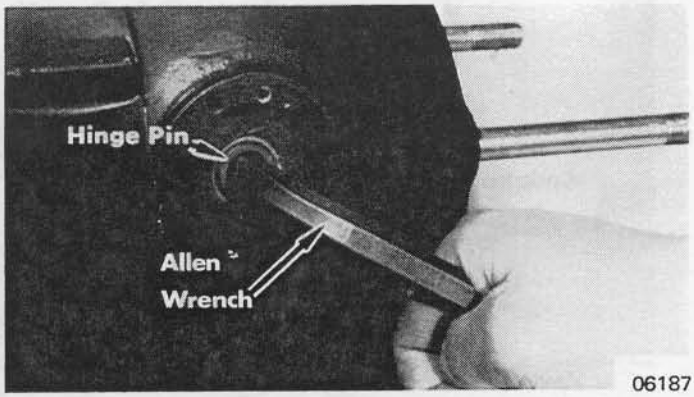


Figure 1. Removing Hinge Pin

2. Remove hinge pins with 9/16 allen wrench. (Figure 1)
3. Loosen bellows clamp to remove bellows. (Figure 2)
4. Remove oil hoses and oil check valve (if necessary).

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air. DO NOT allow solvent to remain on bellows, or bellows will become unserviceable.
2. Inspect bellows for cracks, cuts, punctures and flexibility. Clean all old adhesive from bellows with lacquer thinner before reinstalling. If there is a doubt about bellows serviceability, replace bellows.
3. Clean outside diameter of bell housing bellows mounting flanges first with wire brush or sandpaper, then with lacquer thinner.
4. Check bell housing hinge pin threads for damage.

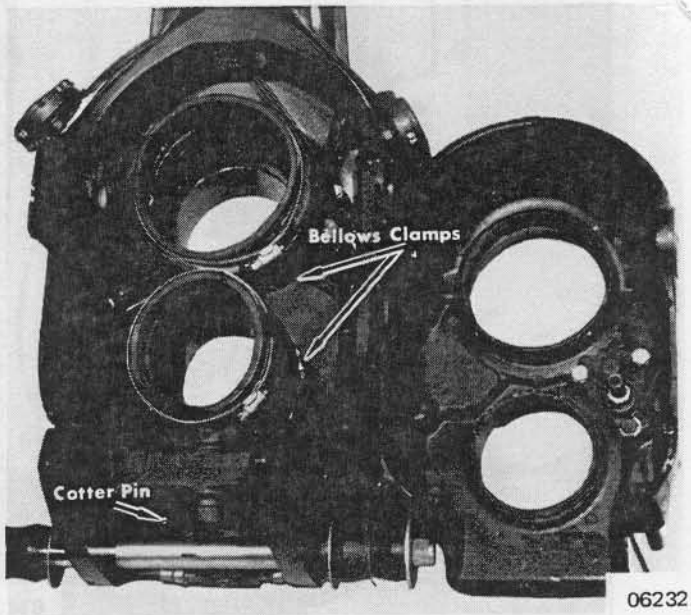


Figure 2. Bellows Clamps

GIMBAL RING

REMOVAL

1. Remove cotter pin, to allow removal of lower swivel pin, and remove swivel pin.
2. Remove allen head screws that hold upper swivel pin in position on gimbal ring. (Figures 3 and 4)

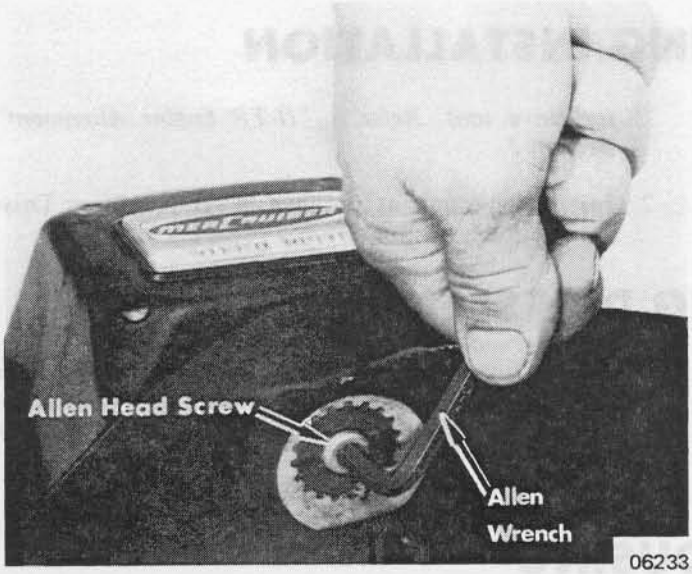


Figure 3. Removing Upper Swivel Pin Screw

3. Remove steering arm screw and nut.
4. Loosen swivel pin elastic stop nut (Figure 5) and remove swivel pin part way with Slide Hammer Puller (C-91-34569A1) and Puller (C-91-38919) thru lower swivel pin hole. (Figure 6) Now remove elastic stop nut from swivel pin and remove lower swivel pin from housing. Gimbal ring now is loose from housing.
5. Remove needle bearing and oil seals from gimbal ring with any 1¼" O.D. mandrel.

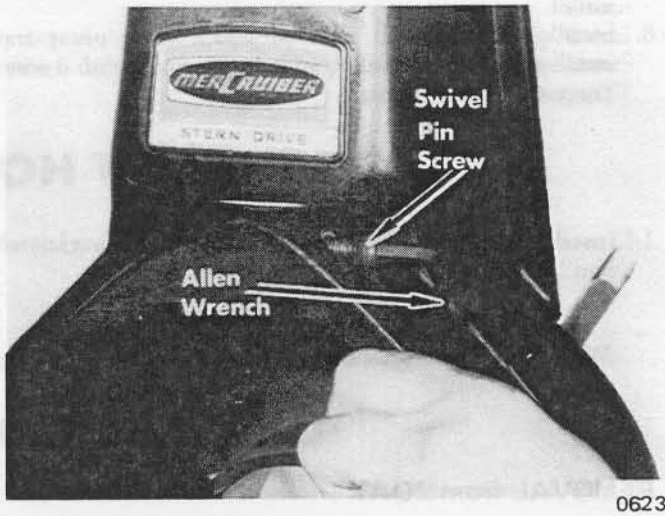


Figure 4. Removing Screw from Swivel Pin

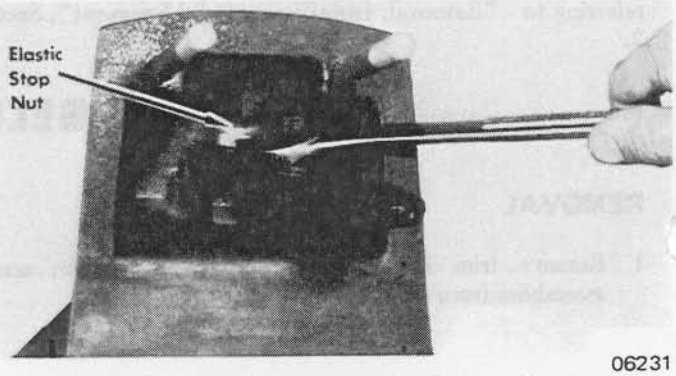
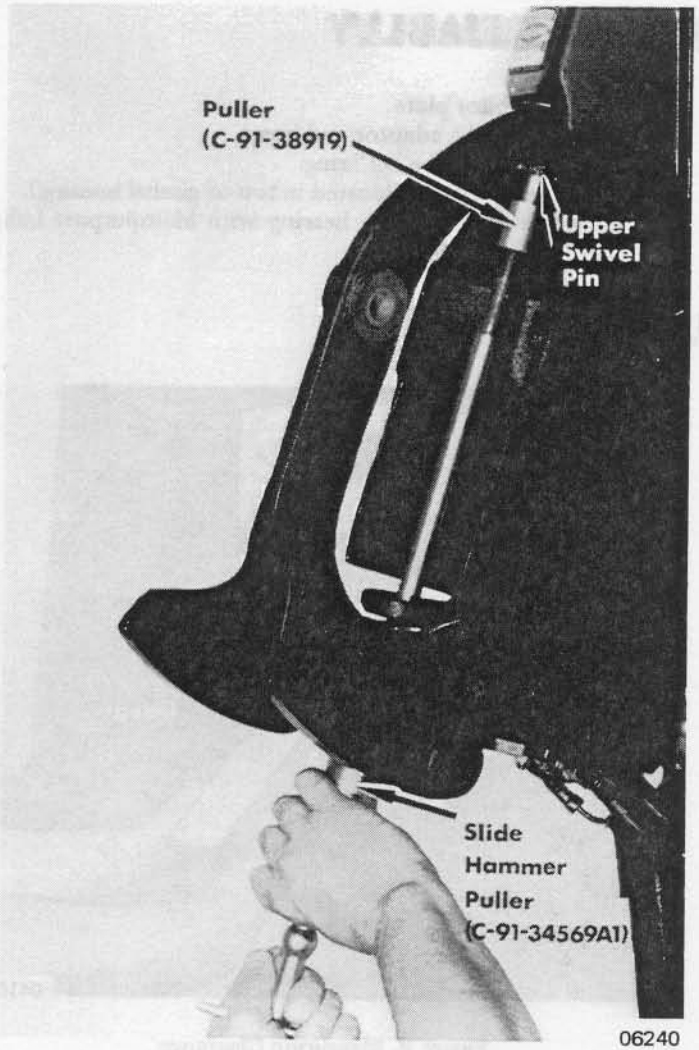


Figure 5. Removing Steering Arm Elastic Stop Nut



CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air. DO NOT allow solvent to remain on oil seals, or seals will become unserviceable.
2. Inspect lower swivel pin where gimbal ring needle bearing rides. If this area of shaft is pitted, grooved, scored, rusty or worn uneven, replace bearing, lower swivel and oil seal.
3. Inspect oil seals for wear, tears and roughness. If there is a doubt about oil seal serviceability, replace oil seals.
4. Check hinge pin bushing (located in gimbal ring) for wear.

Figure 6. Removing Upper Swivel Pin

GIMBAL HOUSING

DISASSEMBLY

1. Remove grease fitting from top of gimbal housing (Figure 7) and remove upper needle bearings and seals with long thin drift, if removal is necessary. NOTE that they will be damaged in removal.
2. Remove inhibitor (zinc) plate.
3. Remove hydraulic adaptor and hoses as required.
4. Be sure to inspect exhaust tube "O" ring and bell housing gasket and replace if necessary.

CLEANING and INSPECTION

1. Clean parts in solvent and dry with compressed air. DO NOT allow solvent to remain on oil seals, or seals will become unserviceable.
2. Check needle bearing for serviceability by inspecting bearing contact surface on upper swivel pin. Pitting, grooves, scoring and uneven wear are reason for bearing, swivel pin and oil seal replacement.
3. Inspect oil seals for wear, tears, roughness and proper spring position. If there is a doubt about oil seal serviceability, replace oil seals.
4. Check hydraulic connector for stripped threads.
5. If inhibitor plate is more than ¼ eaten away, replace plate.

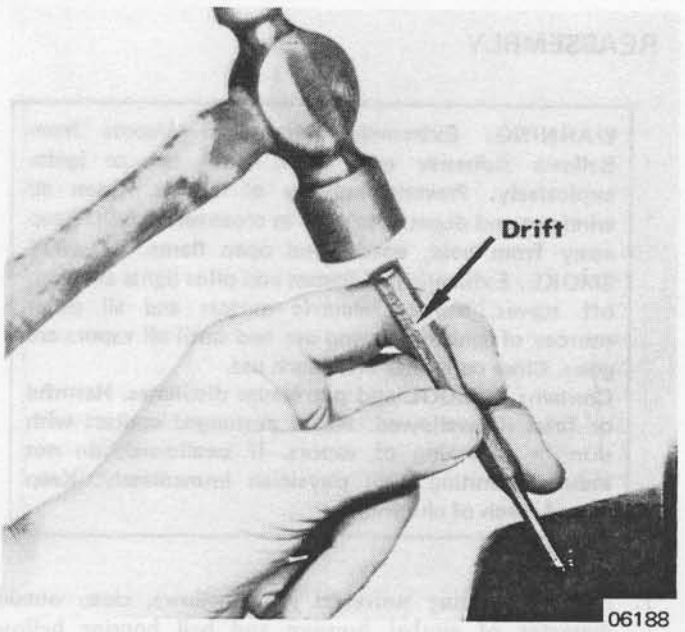


Figure 7. Removing Needle Bearings

6. Clean outside diameter of gimbal housing bellows mounting flanges first with wire brush or sandpaper, then with lacquer thinner.

GIMBAL HOUSING REASSEMBLY

REASSEMBLY

1. Press or drive upper needle bearings with upper small and large oil seals (lips up) into gimbal housing with Driver (C-91-55924).
2. Install inhibitor plate.
3. Install hydraulic adaptor and hoses.
4. Install exhaust tube "O" ring.
5. Install grease fitting (located in top of gimbal housing).
6. Lubricate upper needle bearing with Multipurpose Lubricant (C-92-63250).

GIMBAL RING

REASSEMBLY

1. Press or drive lower needle bearing and lower oil seals (lip up) into gimbal ring with Driver (C-91-55924).
2. Install hinge pin bushings in gimbal ring and epoxy in place with Epoxy Kit (C-92-33673).

INSTALLATION

1. Align gimbal ring with gimbal housing and install lower swivel pin and cotter pin.
2. Install upper swivel shaft washers between gimbal ring and housing and under steering arm, placing elastic stop nut over shaft as it is installed.
3. Install steering arm screw and nut, but do not tighten.
4. Install allen head screw (located at upper starboard side of gimbal ring) with Perfect Seal (C-91-34227) and torque to specifications.
5. Install allen head pipe plug (located in bottom of swivel shaft) with Perfect Seal.
6. Tighten elastic stop nut on swivel pin, pulling up on gimbal ring to obtain .005" to .007" (.127 to .178mm) clearance between washer and gimbal ring. (Figure 8)
7. Torque steering arm screw and nut to specifications.

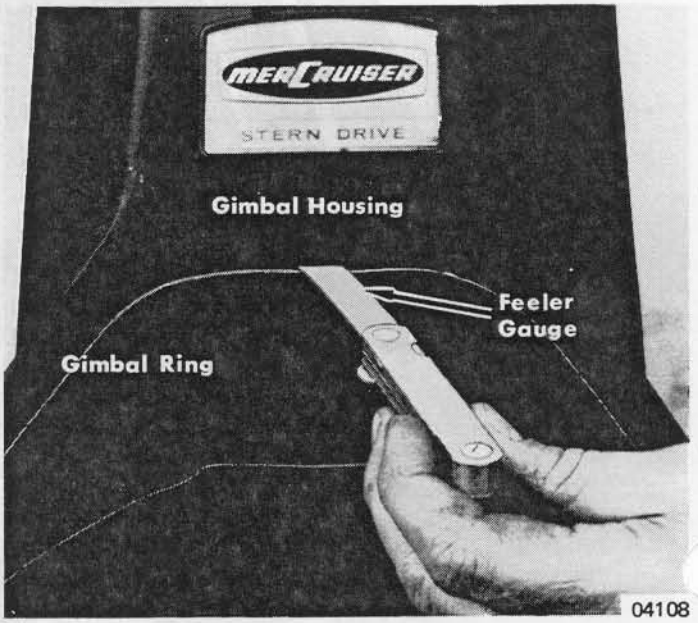


Figure 8. Measuring Clearance

BELL HOUSING

REASSEMBLY

WARNING: Extremely flammable! Vapors from Bellows Adhesive may cause flash fire or ignite explosively. Prevent buildup of vapors. Open all windows and doors. Use only in cross-ventilation. Keep away from heat, sparks and open flame. DO NOT SMOKE. Extinguish all flames and pilot lights and turn off stoves, heaters, electric motors and all other sources of ignition during use and until all vapors are gone. Close container after each use.
Contains TOLUOL and petroleum distillates. Harmful or fatal if swallowed. Avoid prolonged contact with skin or breathing of vapors. If swallowed, do not induce vomiting. Call physician immediately. Keep out-of-reach of children.

1. Before installing universal joint bellows, clean outside diameter of gimbal housing and bell housing bellows mounting flanges first with a wire brush or sandpaper, then with lacquer thinner. Clean inside diameter of bellows with lacquer thinner. Apply Bellows Adhesive (C-92-36340A1) to inside diameter of each end of bellows. Bellows is marked "Top", "FWD" and "AFT". Use these references when installing bellows.
2. Install bellows with clamps and tighten clamps to specifications. Retighten bellows clamps after 3 to 4 hours.
3. Install exhaust bellows in same manner, without bellows adhesive.
4. Reinstall oil check valve.

INSTALLATION

1. Lubricate spacer washers with Multipurpose Lubricant (C-92-63250) and place them over hinge pin bushings. Position bell housing in gimbal ring.
2. Prime clean hinge pin threads in bell housing with Locquic Primer "T" (C-92-59327). Follow instructions on container, then apply Loctite No. 35 (C-92-59328) on threads. Install hinge pins and torque them to specifications.
3. Install oil hose between fittings on valve cover and gimbal housing, tightening hose clamps to specifications.
4. Check universal joint bellows carefully for kinks or uneven folds.

TRIM SWITCH and TRIM SENDER INSTALLATION

1. Thread switch and sender leads into gimbal housing. Install switch lead retainer and tighten screws to 12 ft. lbs. (1.66mkg). Observe position of leads so that they will not interfere with gimbal ring at full starboard turn. Sender leads must point downward 0° to 30°.
2. Align marks on housing and hex rotor shaft (Figure 1) before installing on gimbal ring.
3. Align shaft with hinge pin hex and push into position.
4. Follow trim limit or trim indicator adjustment, following.
5. Install and tighten adjusting screws.
6. Connect trim sender lead with purple sleeve to purple/white wire of trim indicator leads.
7. Connect black trim sender lead to black lead of trim indicator leads.

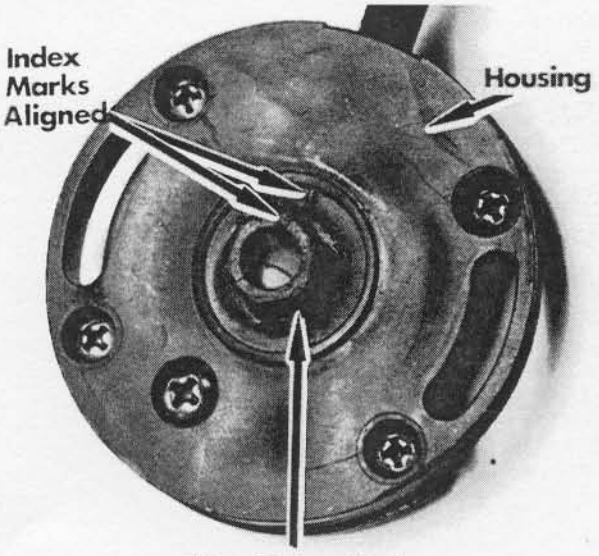


Figure 1. Alignment Marks

TRIM LIMIT READJUSTMENT

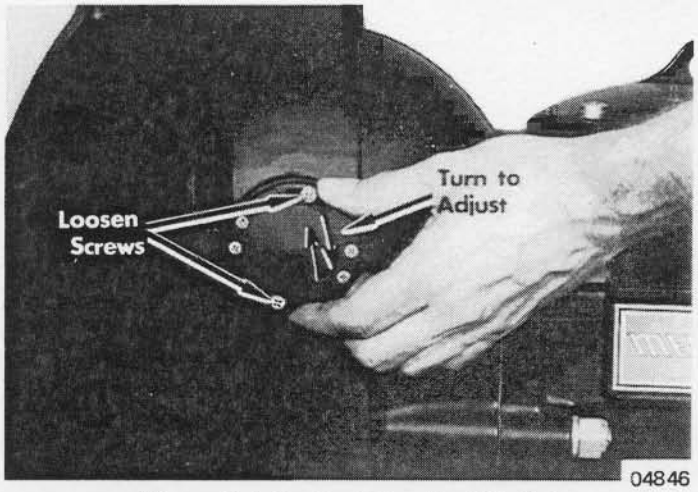


Figure 2. Adjusting Trim Limit Switch

Limiting the drive unit outward trim travel is necessary to ensure safe control at high speeds with certain boats. These boats become difficult to control when the drive is trimmed out too far. Readjustment of the trim limit switch, to restrict the drive's outward travel, will keep it within a safe trimming range.

1. Place drive at maximum desired outward travel (trim) position.
2. Turn stern drive hard to right (starboard).
3. Remove limit switch leads from harness and connect leads to continuity meter.
4. Loosen adjusting screws (Figure 2) which hold trim limit switch. It is normally in the closed circuit position.
5. Rotate switch housing in either direction until switch circuit just opens.
6. Tighten adjusting screws and reconnect switch leads to complete adjustment.

TRIM INDICATOR SENDER ADJUSTMENT

The following procedure is for fine adjustment of instrument needle to bottom of green arc on instrument face.

1. Turn stern drive hard to left (port) in the full "Down" trim position.
2. Loosen 2 adjusting screws (Figure 2) which hold Indicator Sender.
3. Turn ignition key to "Run" position.
4. Rotate Indicator Sender housing in either direction (Figure 2) to show indicator instrument needle on bottom of green arc. (Figure 3)
5. Tighten adjusting screws, check instrument reading and turn ignition key to "Off" position.

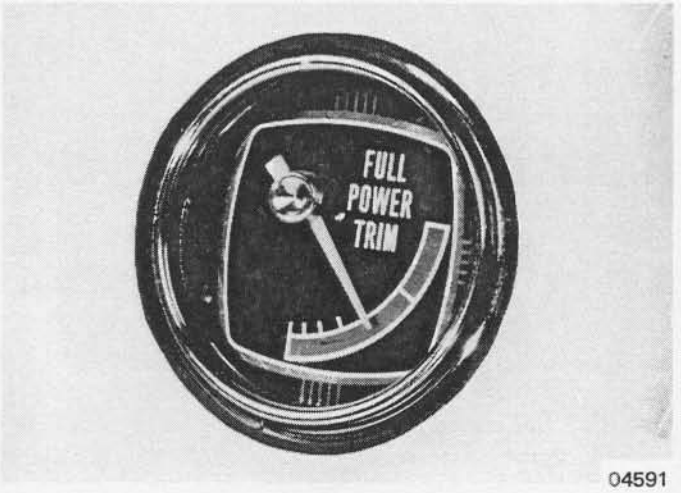
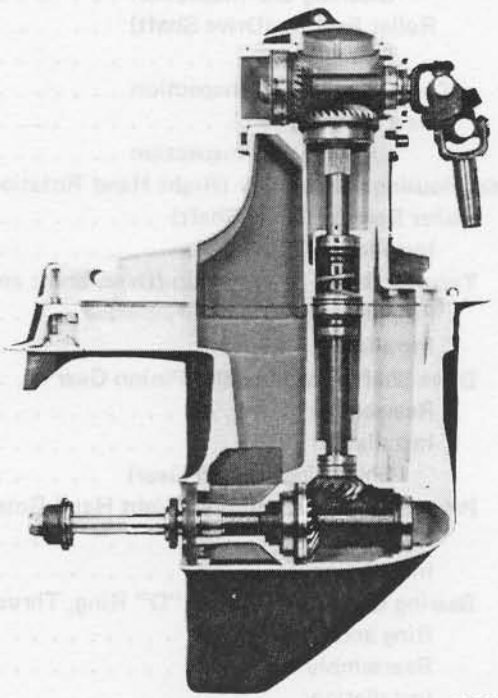


Figure 3. Trim Indicator Instrument

SECTION 6 - DRIVE SYSTEMS

mercruiser

PART C - MERCRUISER II - TRS DRIVE UNIT



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MERCURY MARINE

A BRUNSWICK COMPANY

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MERCRUISER II-TRS DRIVE UNIT
SERVICE RECOMMENDATIONS

Instructions are printed in the sequence which will be followed to assure best results when removing or replacing components. Follow "Disassembly" and "Reassembly" procedures as written. If complete disassembly is not necessary, however, start reassembly at point disassembly was stopped. (Use "Index".) In order to assure correct and durable operation after assembly, it is important that all adjustments and torque value specifications be maintained to the highest degree of accuracy.

Use special service tools, where specified, and use common tools of proper fit when removing and replacing parts.

When holding housings or parts in a vise -- or by other means -- use blocks of wood and/or brass shields to prevent marring parts' surfaces. Pressed-on parts (bearings, gears, etc) require adapting appropriate mandrels and supports for the press used. Do not apply force on the bearing cages, mating surfaces or edges which will mar or fail if force is applied.

DO NOT spin bearings with compressed air, as bearings may be damaged, and it can be dangerous.

To prevent corrosive action, apply Perfect Seal (C-92-34227) to external parts of bearing carrier, bearing carrier retainer and housing mating surfaces during reassembly. DO NOT allow sealer to contact "O" rings or enter bearings and gears. To ease installation of drive unit components, apply Multipurpose Lubricant (C-92-63250) to the lip of all oil seals and "O" rings.

To prevent oil leakage, apply Loctite Type "A" (C-92-32609-1) on outside diameter of all metal case oil seals. When using Loctite on oil seals or threads, surfaces must be clean and dry.

Refer to Section 8, "Specifications", for all torque specifications.

Keep a record of shim amounts and location. Be sure to follow shimming instructions closely. Gears must be mounted to correct feeler gauge reading and correct gear backlash to avoid noisy performance and premature failure. Bearing preload must be within specifications, or bearing failure may result.

Threaded parts are right hand (RH), unless otherwise indicated. Drive unit should be completely disassembled, inspected and cleaned, if either gear housing or drive shaft housing has indicated a failure.

A suitable mandrel for pressing tapered roller bearings on shafts and gears can be obtained from the old bearing. Cut outer cage off inner race with hack saw. (Figure A) Remove cage and bearing rollers. Inner race (used as a mandrel) will apply pressing force to inner race of new bearing without damaging bearing cage, rollers or races. Remove bearings from gears or shafts only if replacement is necessary.

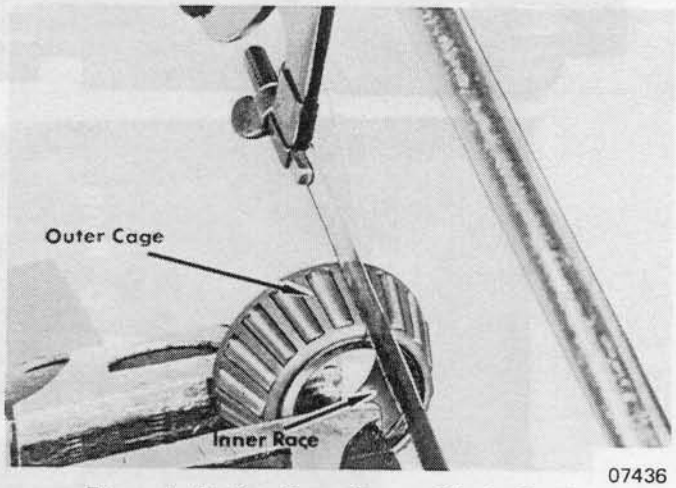

Figure A. Cutting Outer Cage to Obtain Mandrel

GEAR HOUSING ASSEMBLY

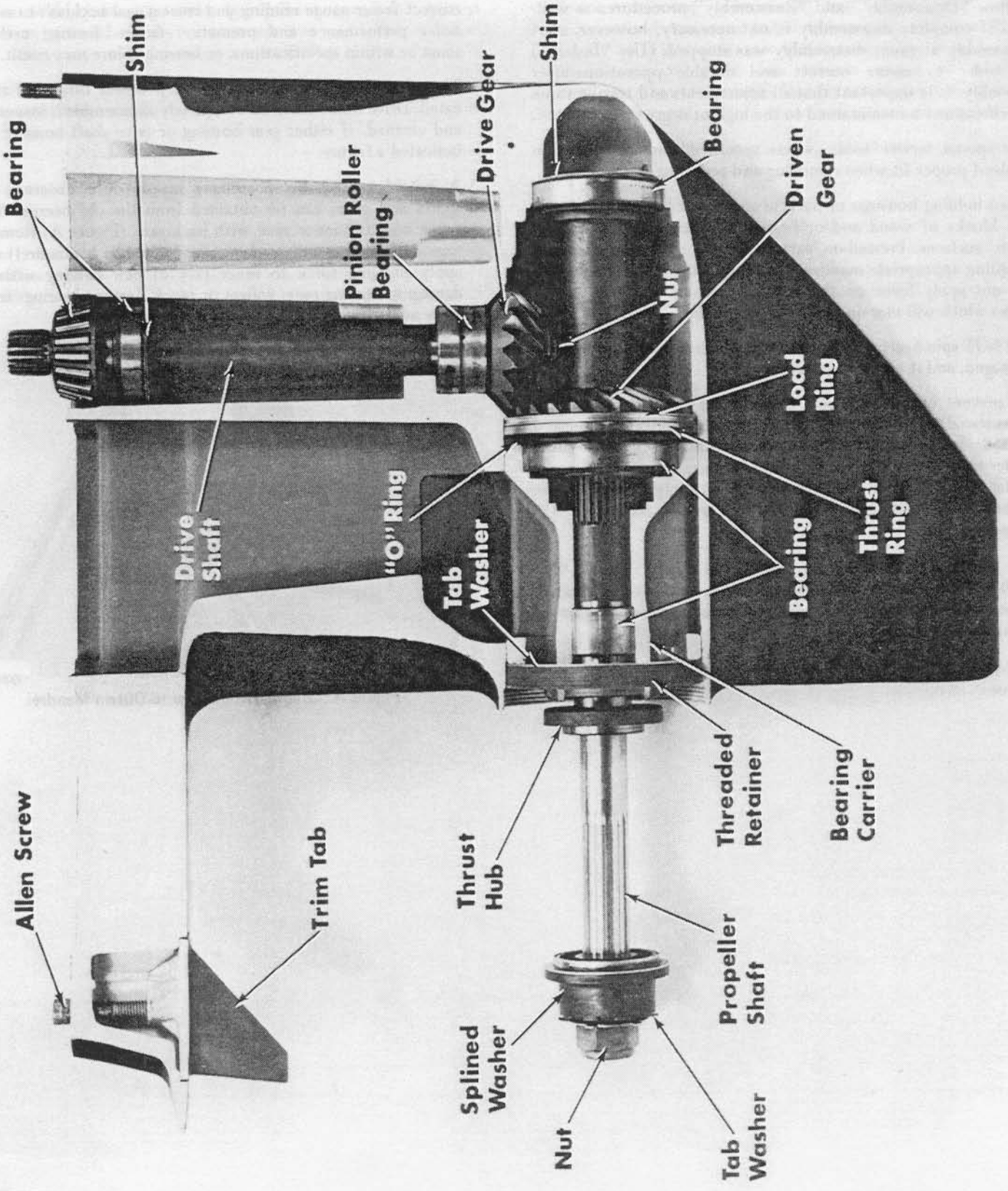

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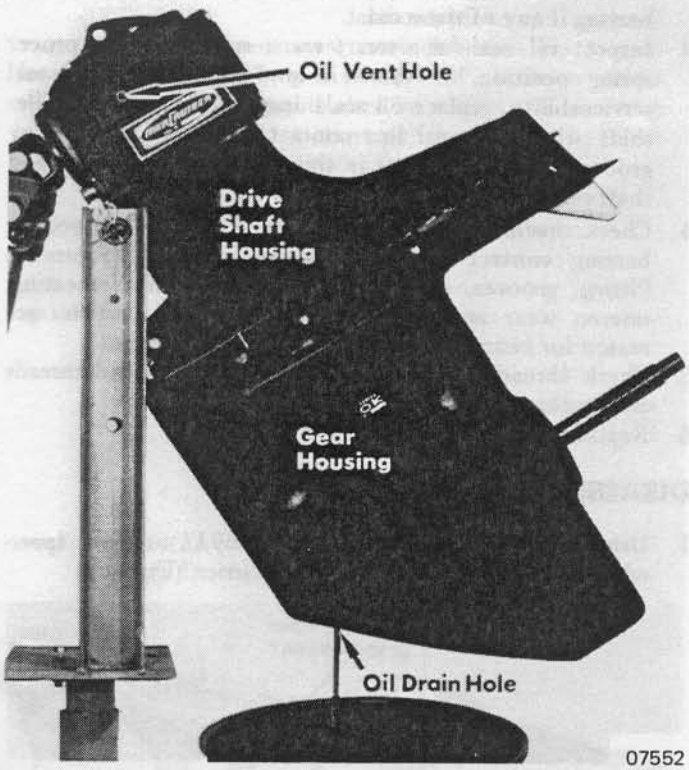
Figure B. Gear Housing Parts Identification (Right Hand Rotation)

GEAR HOUSING REMOVAL



1. Remove complete drive unit from bell housing as in "Drive Shaft Housing Removal", Section 2.
2. Drain gear lubricant. Check lubricant for metal particles or water.
   a. If metal particles are found, disassemble complete drive unit. Clean all parts in solvent (especially bearings) and dry with compressed air.
   b. If water is found, disassemble complete drive unit. Clean all parts in solvent and dry with compressed air. Apply a light coat of oil to all parts to prevent rusting. Check housings for impact damage and replace all "O" rings and oil seals.
3. Remove propeller and trim tab.
4. Remove allen head screw located under trim tab. Remove 7 nuts and separate gear housing from drive shaft housing.

Figure 1. Draining Lubricant

GEAR HOUSING DISASSEMBLY - RIGHT HAND ROTATION

IMPORTANT: Follow "General Service Recommendations" (see "Index").

BEARING CARRIER (CARRIER RETAINER and TAB WASHER)

IMPORTANT: Before disassembly, position dial indicator on machined surface of propeller shaft just behind bearing carrier. Push propeller shaft to one side and hold in this position while zeroing dial indicator. Move propeller shaft to opposite side. Shaft deflection should be max .003" (.076mm). DO NOT turn propeller shaft. Repeat procedure, moving shaft up-and-down. If shaft deflection is more than .003", shaft and/or needle bearing is worn, or propeller shaft is undersize.

REMOVAL

1. Mount gear housing assembly on Repair Stand (C-91-33750) with Adaptor (C-91-60524A1).
2. Straighten locking tab and loosen threaded retainer with Retainer Tool (C-91-61069 or C-91-53126). (Figure 1) Remove retainer and tab washer.
3. Remove bearing carrier with Slide Hammer (C-91-34569A1) and Bearing Carrier Puller (C-91-45086A1). (Figure 2) Be careful not to lose carrier alignment key.

Figure 1. Removing Threaded Retainer

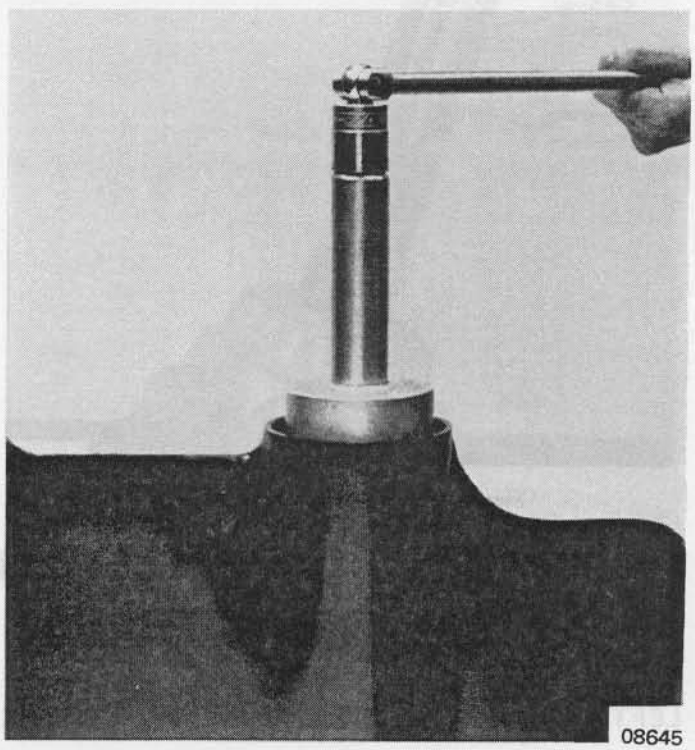


Figure 2. Removing Bearing Carrier

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air. DO NOT allow solvent to remain on oil seals, or seals will become unserviceable.

Figure 3. Propeller Shaft Surface

2. Check propeller shaft bearing cup for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles. Replace bearing cup and bearing if any of these exist.
3. Inspect oil seals for wear, tears, roughness and proper spring position. If there is any doubt about oil seal serviceability, replace oil seals. Inspect surface of propeller shaft where oil seal lips contact shaft. (Figure 3) Any groove in propeller shaft in this area requires oil seals and shaft replacement.
4. Check needle bearing for serviceability by inspecting bearing contact surface on propeller shaft. (Figure 3) Pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles are reason for bearing and propeller shaft replacement.
5. Check threaded retainer for broken or corroded threads and cracks.
6. Replace tab washer. DO NOT re-use.

DISASSEMBLY

1. Using Slide Hammer Tool (C-91-34569A1), remove tapered roller bearing cup from bearing carrier. (Figure 4)

Figure 4. Removing Bearing Cup

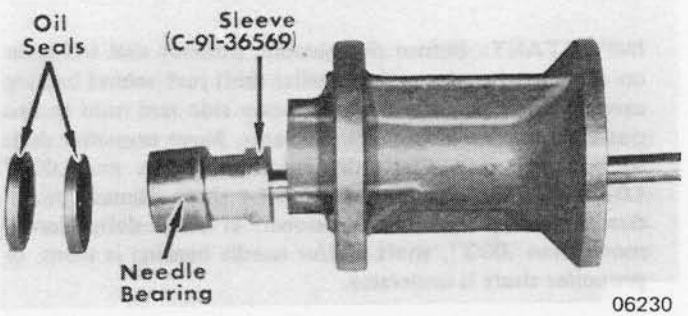


Figure 5. Removing Seals and Bearing

2. Using Sleeve Tool (C-91-36569) and Driver Rod Tool (C-91-37323), remove needle bearing and 2 oil seals from carrier. (Figure 5)

   NOTE: Seals can be removed separately with Slide Hammer (C-91-34569A1).

PROPELLER SHAFT ASSEMBLY ("O" RING, THRUST RING and LOAD RING)

LEFT HAND ROTATION VARIATIONS

1. Left hand propeller shaft, front bearing and driven gear bearing have part numbers different than right hand rotation parts. These parts are not interchangeable and are assembled differently, as shown in Figure 6.

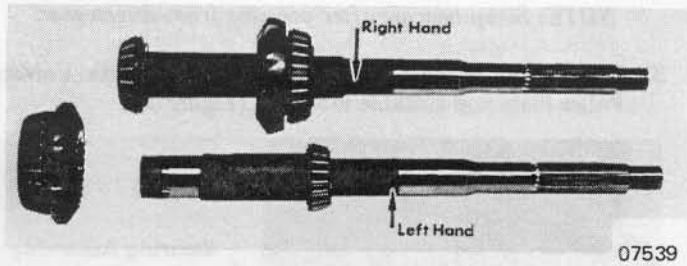


Figure 6. R.H. and L.H. Propeller Shaft Assemblies

2. Driven gear on left hand rotation is not a press fit to propeller shaft and is installed into gear housing before pinion gear is installed. Propeller shaft then is set into driven gear.
3. Gear shimming and preload are adjusted at same locations for left hand and right hand rotation units.

CAUTION: Propeller must be matched to rotation of drive unit.

REMOVAL

1. Lift propeller shaft straight up (about 3" or 4" [7.6 or 10.2cm]) to unseat thrust ring, "O" ring and load ring. Set propeller shaft back into its normal running position in gear housing and lift the "O" ring, thrust ring and load ring out of gear housing.

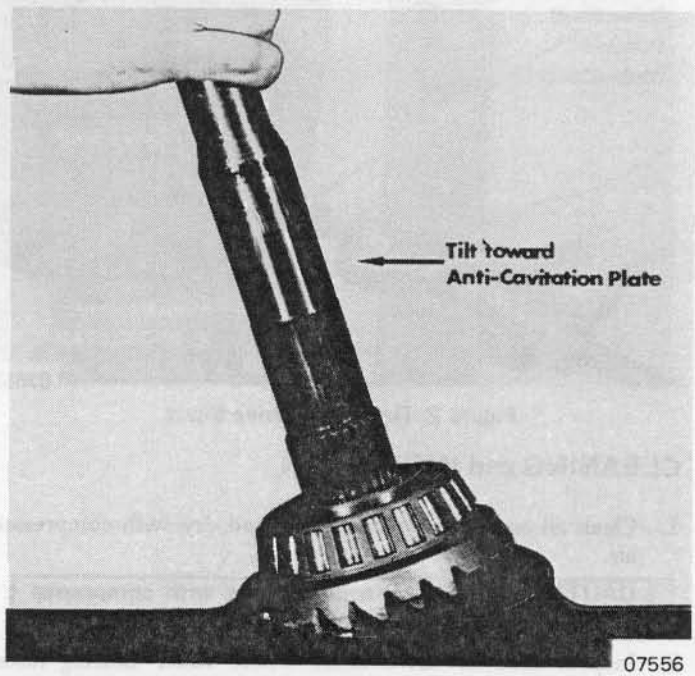


Figure 7. Removing Propeller Shaft

2. To prevent damaging propeller shaft bearing on pinion gear, tilt propeller end of shaft toward anti-cavitation plate while removing shaft from housing. (Figure 7)

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air.

CAUTION: DO NOT spin bearings with compressed air, as bearings may be damaged.

2. Check propeller shaft tapered roller bearings by inspecting bearing cups. Pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles are all reasons for replacement. Replace both bearing and bearing cup.
3. Inspect propeller shaft where bearing carrier needle bearing rides. (Figure 7) Replace propeller shaft and needle bearing if shaft is pitted, grooved, scored, discolored from overheating, worn uneven or has embedded foreign metal particles.
4. Inspect surface of propeller shaft where bearing carrier oil seal lips contact shaft. (Figure 7) Any groove in shaft in this area requires replacement of shaft and oil seals.
5. Inspect driven gear (right hand rotation) for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear if any of these exist.

NOTE: On left hand rotation, pinion gear and drive shaft must be removed before removal of driven gear.

6. Check propeller shaft for straightness:
   a. Place propeller shaft on balance wheels and spin shaft. Observe shaft for wobble on propeller end of shaft. Replace if bent.
   b. Place propeller shaft on "V" blocks. Rotate shaft. If propeller end of shaft wobbles, replace shaft.
   c. Place shaft between centers in lathe. Place dial indicator in area of needle bearing. If total indicator variation is greater than .005" (.127mm) as shaft is revolved, replace shaft.
7. Clean all corrosion from propeller shaft splines. If splines are partially corroded away, replace shaft.
8. Inspect "O" ring for cuts, nicks, hardness and cracks. If there is any doubt about "O" rings serviceability, replace "O" ring.
9. If gear housing or any internal gear housing components have been changed, a NEW load ring must be used.

DISASSEMBLY (Right Hand Rotation)

NOTE: For left hand rotation propeller shaft differences refer to "Left Hand Rotation Variations" (see "Index").

1. Press driven gear and bearing assembly from propeller shaft with Universal Puller Plate Tool (C-91-37241). (Figure 8)

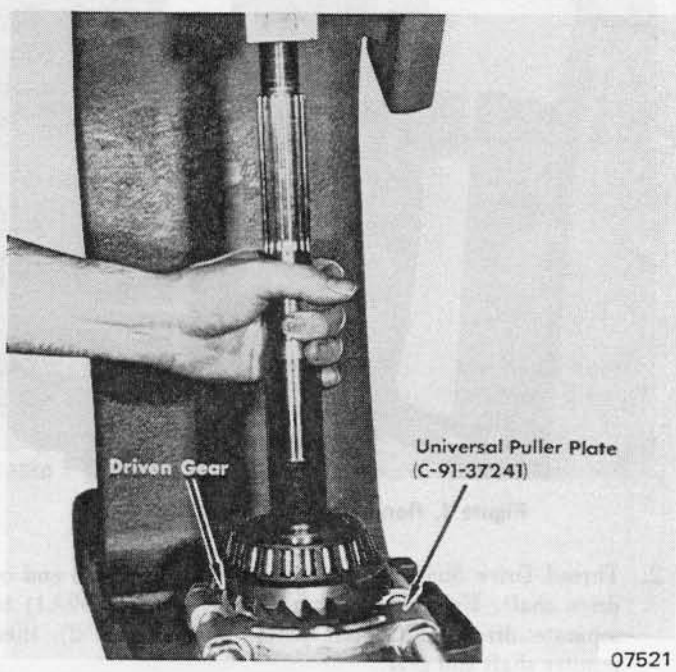


Figure 8. Removing Propeller Shaft from Driven Gear

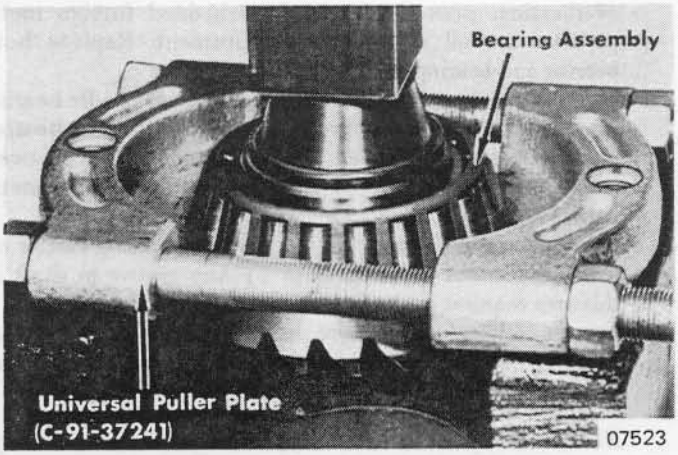


Figure 9. Removing Bearing from Driven Gear

NOTE: Remove bearing from gear only if replacement is necessary.

2. Using Universal Puller Plate Tool and suitable mandrel, press driven gear bearing from driven gear. (Figure 9)

NOTE: Scrap bearing after pressing from driven gear.

3. Press front bearing from propeller shaft with Universal Puller Plate and suitable mandrel. (Figure 10)

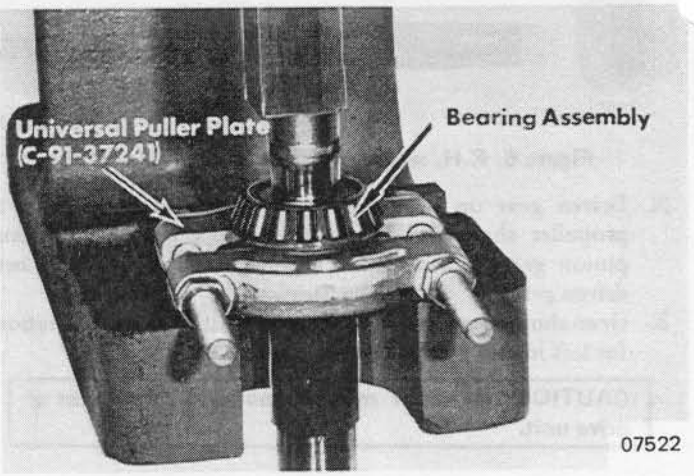


Figure 10. Removing Front Bearing from Shaft

DRIVE SHAFT ASSEMBLY and PINION GEAR

REMOVAL

1. Reinstall carrier retainer nut to protect threads in housing. Use Drive Shaft Socket Tool (C-91-63620A1) and remove pinion gear nut and washer. (Figure 1)

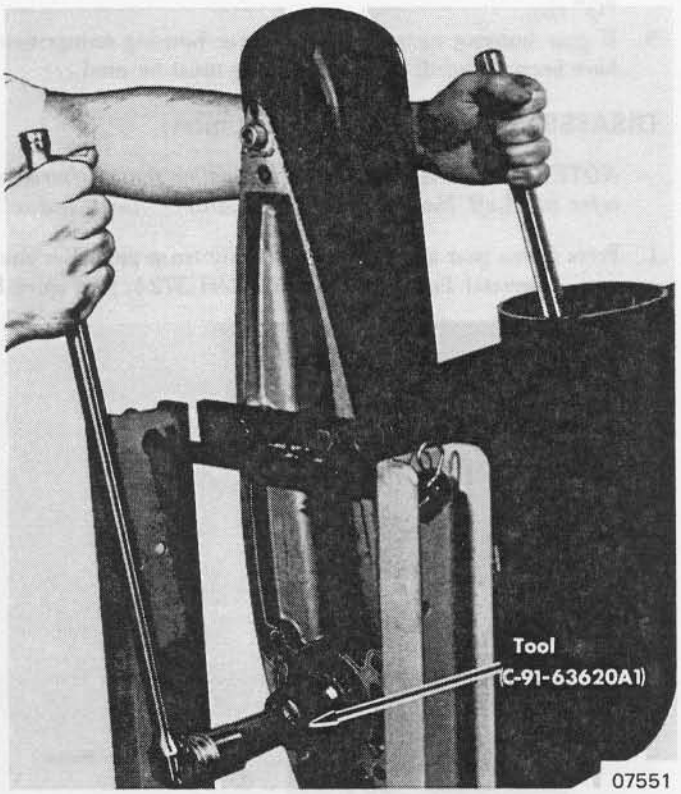


Figure 1. Removing Pinion Gear Nut

2. Thread Drive Shaft Puller Tool (C-91-63616) into end of drive shaft. Use Slide Hammer Tool (C-91-34569A1) to separate drive shaft from pinion gear (Figure 2), then remove shaft and gear.

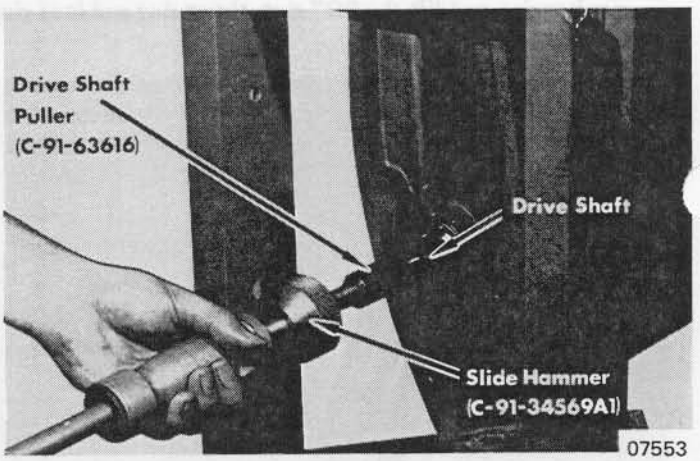


Figure 2. Removing Drive Shaft

CLEANING and INSPECTION

1. Clean all components in solvent and dry with compressed air.

CAUTION: DO NOT spin bearings with compressed air, as bearings may be damaged.

2. Inspect area of drive shaft where roller bearing rides. Pitting, grooves, scoring, uneven wear, discoloration from overheating and embedded foreign metal particles are all reasons for replacement of drive shaft and roller bearing.
3. Check drive shaft upper and lower tapered roller bearings by inspecting bearing cups. Replace bearings and bearing cups if cups are pitted, grooved, scored, worn uneven, discolored from overheating or have foreign metal particles embedded in cup.
4. Inspect drive shaft splines (both ends) for wear.
5. If propeller shaft was bent, check drive shaft for straightness.
6. Inspect drive (pinion) gear for pitting, chipped or broken teeth and excessive or uneven wear. Replace gear if any of above exist.

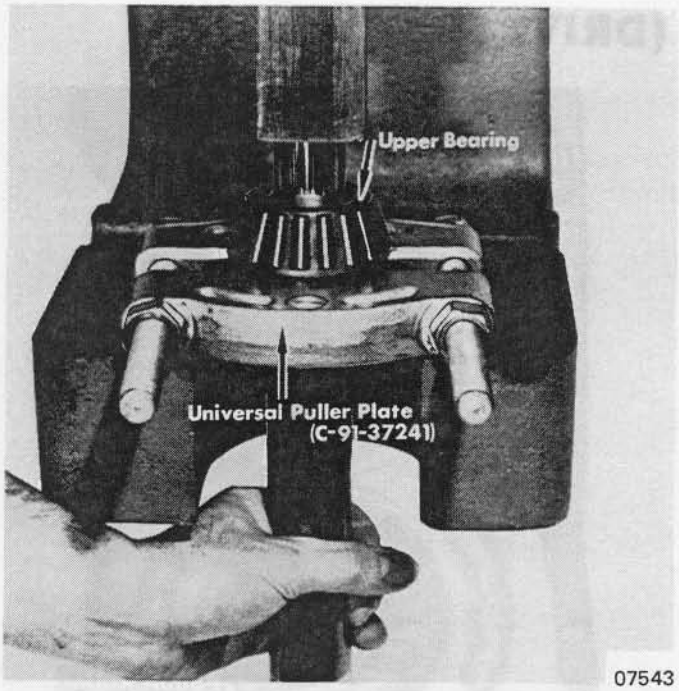


Figure 2. Pressing Upper Bearing from Shaft

DISASSEMBLY

1. Press upper bearing from drive shaft with Universal Puller Plate Tool (C-91-37241). (Figure 2)
2. Use Universal Puller Plate to press lower bearing from drive shaft. (Figure 3)

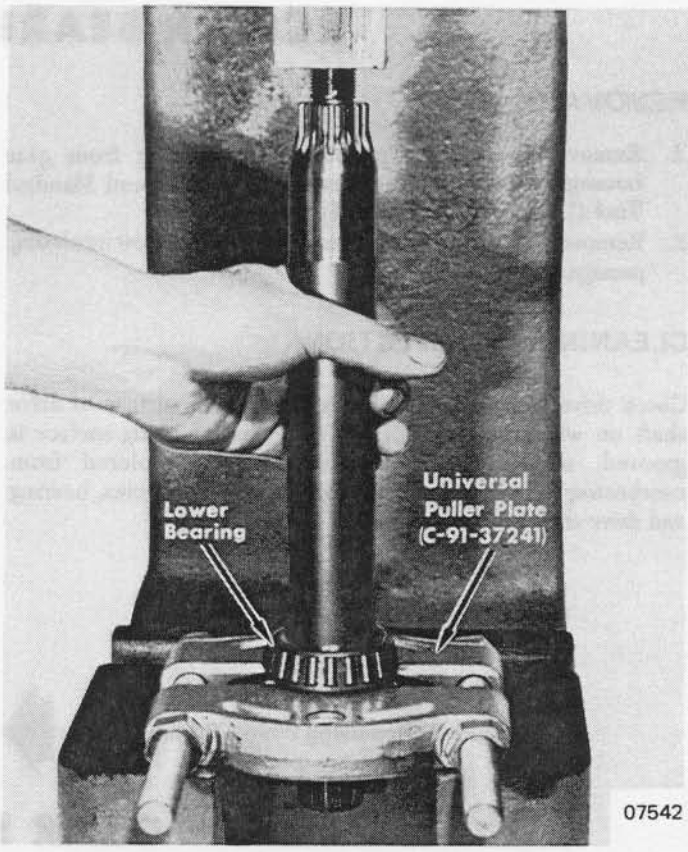


Figure 3. Pressing Lower Bearing from Shaft

TAPERED ROLLER BEARING CUP (DRIVE SHAFT and PROPELLER SHAFT)

REMOVAL

Using Slide Hammer Tool (C-91-34569A1), remove small drive shaft tapered roller bearing cup from gear housing (Figure 4) and remove shims. Using same procedure, remove propeller shaft tapered roller bearing cup from gear housing and remove shims.

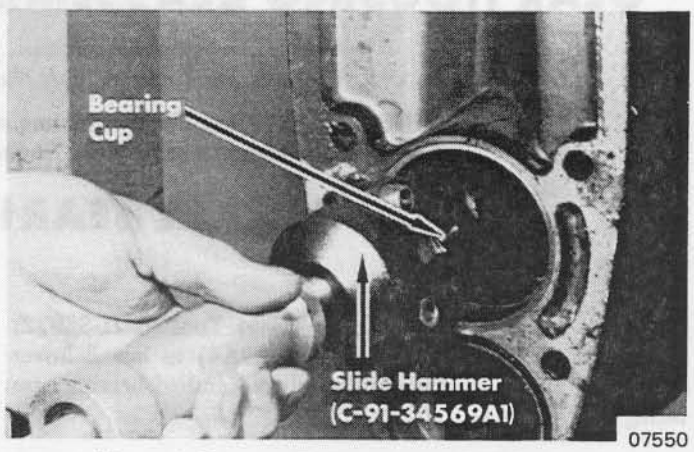


Figure 4. Remove Tapered Roller Bearing Cup

CLEANING and INSPECTION

Inspect bearing cups for pitting, grooves, scoring, discoloration from overheating, uneven wear and embedded foreign metal particles and replace bearing cup and bearing if any of these exist.

ROLLER BEARING (DRIVE SHAFT)

REMOVAL

1. Remove drive shaft (pinion) roller bearing from gear housing with Driver Rod Tool (C-91-37323) and Mandrel Tool (C-91-55917). (Figure 5)
2. Remove "O" ring from gear housing oil recirculating passage.

CLEANING and INSPECTION

Check drive shaft roller bearing by inspecting surface of drive shaft on which bearing rides. If drive shaft bearing surface is grooved, scored, pitted, worn unevenly, discolored from overheating or has embedded foreign metal particles, bearing and drive shaft must be replaced.

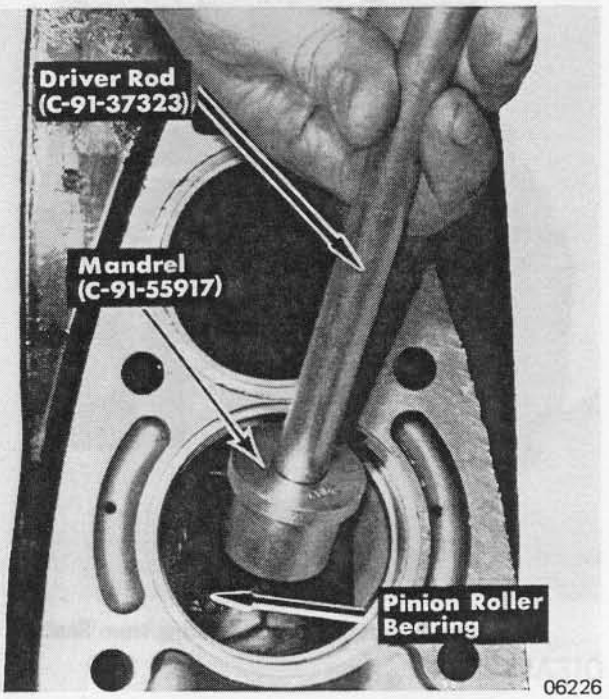


Figure 5. Removing Pinion Roller Bearing

GEAR HOUSING

CLEANING and INSPECTION

1. Clean assembly in solvent and dry with compressed air.
2. Check gear housing carefully for impact damage.
3. Check for loose fitting bearing cups and needle bearings.

NOTE: Lower drive shaft (located in gear housing) upper bearing cup should be a loose fit in gear housing.

4. Inspect bearing carrier retainer threads in gear housing for corrosion or stripped threads.

GEAR HOUSING REASSEMBLY - RIGHT HAND ROTATION

NOTE: For left hand rotation, follow right hand rotation instructions, following, and refer to "Left Hand Rotation Variations" (see "Index").

IMPORTANT: Install same amount of shims that were removed. Follow "General Service Recommendations" (see "Index"). Refer to Figure B for parts identification.

ROLLER BEARING (DRIVE SHAFT)

INSTALLATION

Use Drive Shaft (Pinion) Bearing Driver Tool (C-91-55922) and Installing Tool (part of C-91-31229A4) to install lower drive shaft pinion bearing with numbered end of bearing case facing up. (Figure 1)

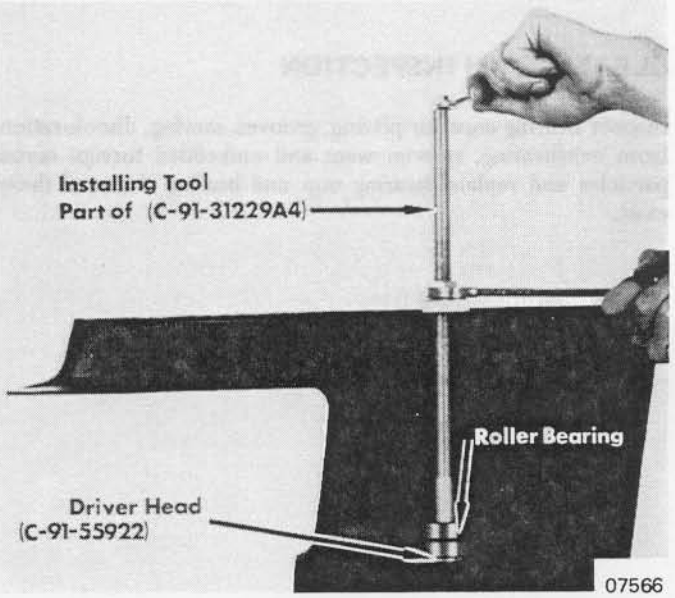


Figure 1. Installing Roller Bearing

TAPERED ROLLER BEARING CUP (DRIVE SHAFT and PROPELLER SHAFT)

INSTALLATION

1. Install shims and use Tool C-91-67443 to install small drive shaft bearing cup. (Figure 2)

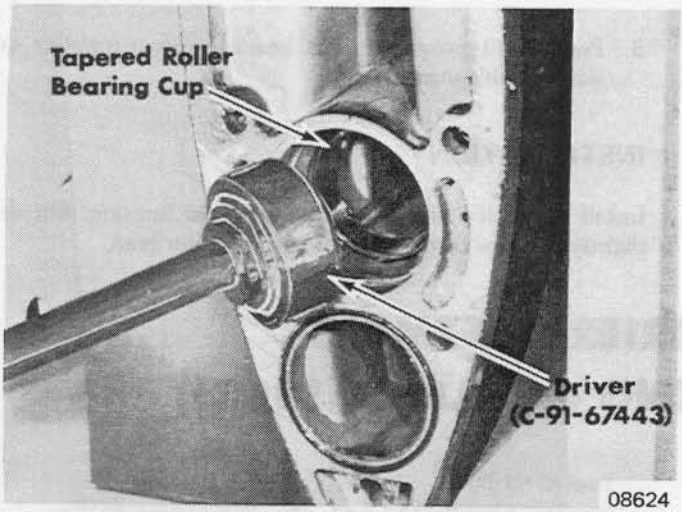


Figure 2. Installing Drive Shaft Bearing Cup

Figure 3. Installing Propeller Shaft Bearing Cup

2. Install shims and use Driver C-91-33493 to install front propeller shaft bearing cup. (Figure 3)

DRIVE SHAFT ASSEMBLY and PINION GEAR

REASSEMBLY

Press lower bearing and upper bearing onto drive shaft with suitable mandrels. (Figure 4)

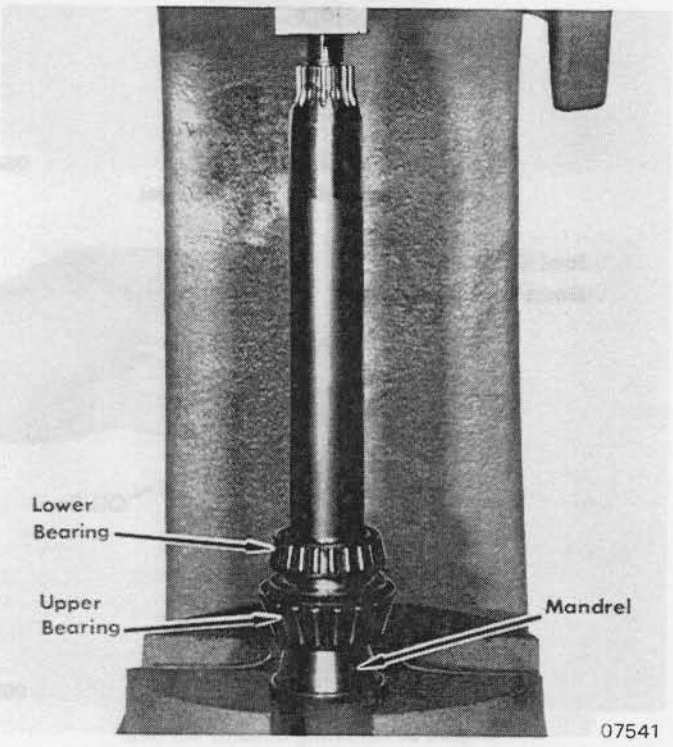


Figure 4. Pressing Upper Bearing on Shaft

INSTALLATION

NOTE: On left hand rotation gear housing, install driven gear before pinion gear and drive shaft.

1. Install drive shaft and bearing assembly into gear housing.
2. Install pinion gear, dished washer (concave side toward pinion gear) and pinion nut. Use Loctite Type "A" (C-92-32609-1) on pinion nut threads, if shimming is correct. Torque to specifications, using Drive Shaft Socket (C-91-63620A1).

Figure 5. Checking Pinion Gear Shimming

SHIMMING (PINION GEAR)

a. Carefully place Shimming Tool (C-91-67441) in gear housing. (Figure 5) Push in on drive shaft to simulate bearing preload and rotate to seat bearing

rollers. Hold drive shaft in this position and measure clearance between tool and gear with a feeler gauge. Clearance must be .025.

b. If clearance is more or less than .025, remove drive shaft, pinion gear and drive shaft small bearing cup. Add or remove shims under bearing cup equal to the difference between .025 and your reading. Reinstall bearing cup, drive shaft and pinion gear. Use Loctite Type "A" (C-92-32609-1) on threads of nut. Recheck clearance.

PROPELLER SHAFT ASSEMBLY - RIGHT HAND ROTATION

REASSEMBLY

NOTE: For left hand rotation propeller shaft differences, refer to "Left Hand Rotation Variations" (see "Index").

1. Use a suitable mandrel and press driven gear bearing onto driven gear.
2. Align driven gear splines with propeller shaft splines and press gear on propeller shaft.
3. Press front propeller shaft bearing onto propeller shaft with suitable mandrel.

INSTALLATION

Install assembled propeller shaft into gear housing. Tilt shaft slightly to allow front bearing to clear pinion gear.

BEARING CARRIER ASSEMBLY ("O" RING, THRUST RING and LOAD RING)

REASSEMBLY

1. Install tapered roller bearing cup in bearing carrier with Driver Tool (C-91-67443). (Figure 6)

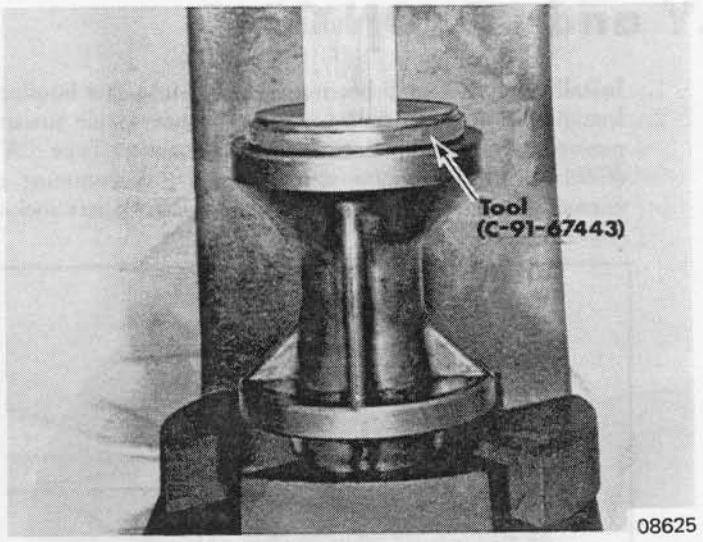


Figure 6. Installing Bearing Cup

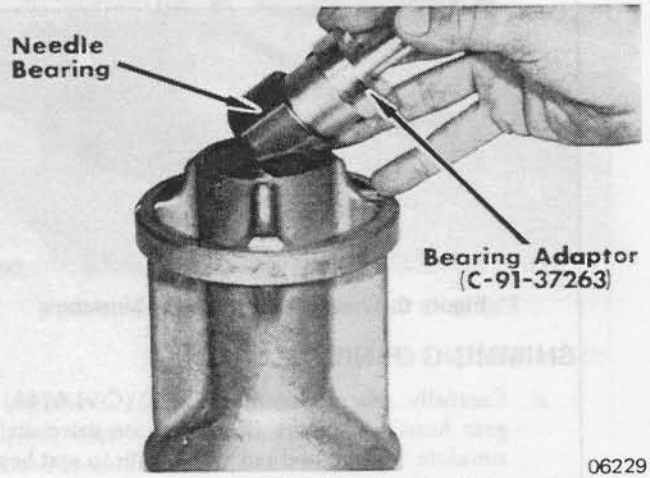


Figure 7. Installing Needle Bearing

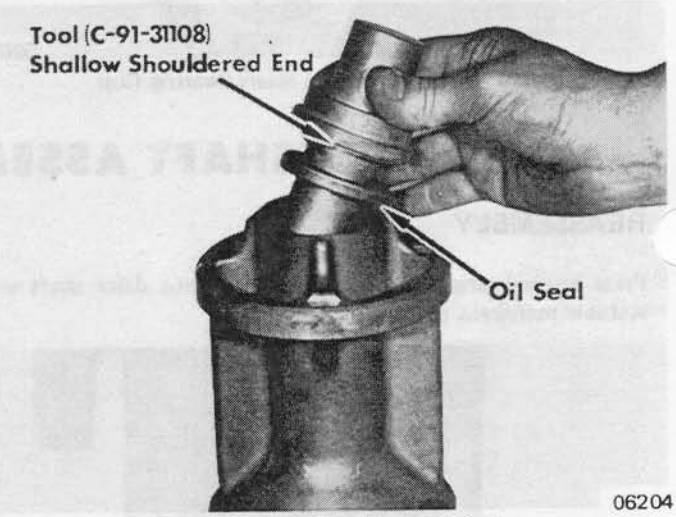


Figure 8. Installing First Oil Seal

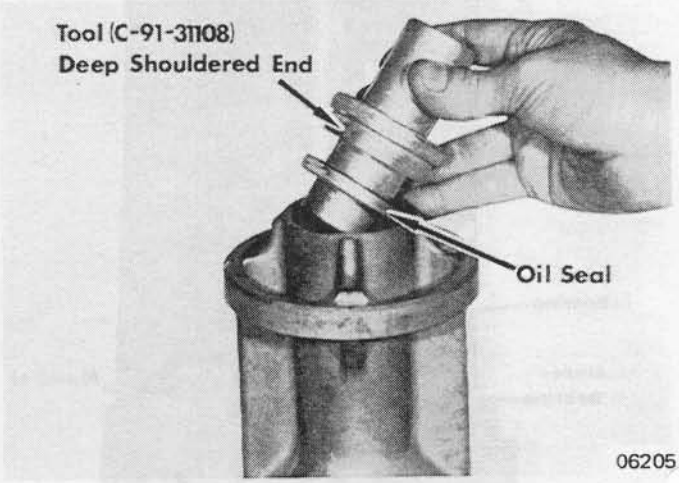


Figure 9. Installing Second Oil Seal

2. Using Bearing Adaptor Tool (C-91-37263), install needle bearing in carrier. (Figure 7)
3. Use deep shouldered end of Driver Tool (C-91-31108) to install first oil seal with lip facing in. (Figure 8)

4. Use shallow shouldered end of Driver Tool (C-91-31108) to install second oil seal with lip facing out. (Figure 9)
5. Fill space between oil seals with Multipurpose Lubricant (C-92-63250).

INSTALLATION

1. Install bearing carrier assembly and carrier locating key into gear housing. DO NOT install propeller shaft load ring, thrust ring or "O" ring at this time.
2. Install threaded bearing carrier retainer WITHOUT tab washer. Torque retainer SLOWLY until sufficient amount of preload is obtained on propeller shaft bearings to check pinion gear backlash.

CAUTION: DO NOT over-torque retainer, or damage may occur to propeller shaft bearings.

3. Position dial indicator on machined surface of propeller shaft just behind bearing carrier. Push propeller shaft to one side and hold in this position while zeroing dial indicator. Move propeller shaft to opposite side. Shaft deflection should be max. .003" (.076mm). DO NOT turn propeller shaft. Repeat procedure, moving shaft up-and-down. If shaft deflection is more than .003", shaft and/or needle bearing is worn or propeller shaft is undersize.

SHIMMING (GEAR BACKLASH)

a. Use Dial Indicator and Indicator Rod (C-91-53459), position Mark III, to check gear backlash which should be .009" to .013" (.229 to .330mm). (Figure 10) Push in on drive shaft to simulate bearing preload and turn drive shaft and pinion gear back-and-forth. Use light turning pressure to prevent propeller shaft from turning. Dial indicator registers amount of gear backlash (clearance) between gear teeth.

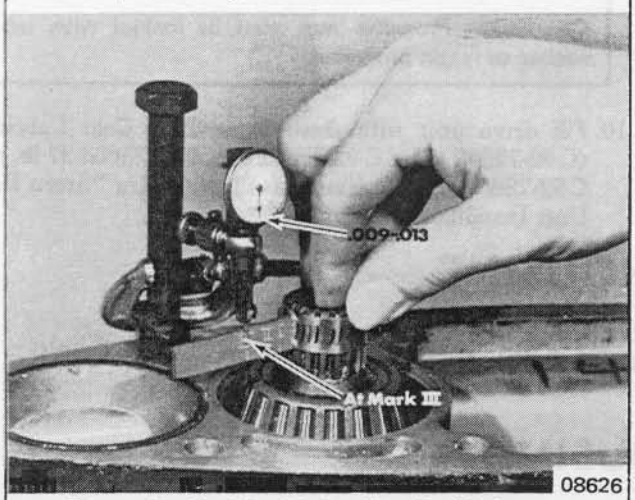


Figure 10. Checking Pinion Gear Backlash

b. Right Hand Rotation: If backlash is more than specified, remove shims from under propeller shaft front bearing cup. If backlash is less than specified, add shims under propeller shaft front bearing cup. Left Hand Rotation: If backlash is more than specified, add shims under propeller shaft front bearing cup. If backlash is less than specified, remove shims from under propeller shaft front bearing cup.

NOTE: If gear housing or any internal gear housing components have been changed, a NEW load ring must be installed.

4. Remove bearing carrier assembly and install load ring, thrust ring and "O" ring into gear housing.
5. Coat outer diameters of bearing carrier with Perfect Seal (C-92-34227) and fill space between oil seals with Multipurpose Lubricant (C-92-63250). Reinstall bearing carrier assembly and carrier locating key into gear housing.
6. Install tab washer. Coat threads of retainer with Perfect Seal and install retainer. Torque retainer SLOWLY (periodically checking propeller shaft bearing preload with inch-pound torque wrench, shown in Figure 11) until correct propeller shaft bearing preload is obtained. See "Specifications" Section 8.

IMPORTANT: DO NOT over-torque retainer to excessive bearing preloads. Over-torque will collapse load ring excessively and require load ring replacement.

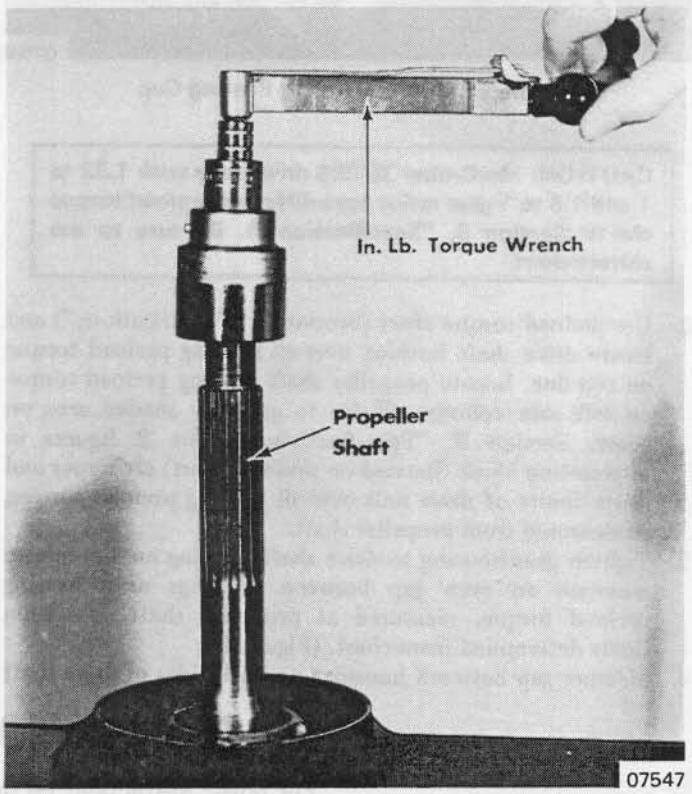


Figure 11. Checking Propeller Shaft Bearing Preload Torque

7. Bend one tab on bearing carrier retainer tab washer into slot provided on retainer.

NOTE: Make a note of propeller shaft bearing preload torque for future use in determining gear housing drive shaft bearing preload torque and drive unit over-all bearing preload torque. Adjust gear housing drive shaft bearing preload torque as illustrated in "Gear Housing Installation" (see Index).

GEAR HOUSING INSTALLATION

NOTE: If gear housing, drive shaft housing, lower drive shaft or lower drive shaft components HAVE NOT been replaced, start installation procedures at step No. 5.

1. Set preload on lower drive shaft tapered roller bearings by over-shimming (.060" [.152mm] or more) lower drive shaft bearing cup (located in drive shaft housing). (Figure 12) Connect gear housing to drive shaft housing with 7 nuts. Do not tighten nuts at this time.

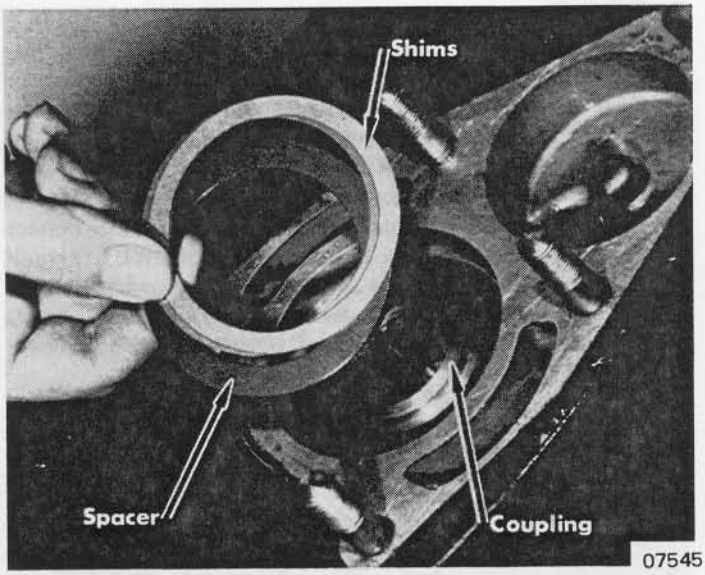


Figure 12. Over-Shimming Bearing Cup

CAUTION: MerCruiser II-TRS drive units with 1.33 to 1 and 1.5 to 1 gear ratios have different preload torque charts (Section 8, "Specifications"). Be sure to use correct chart.

2. Use preload torque chart (Section 8, "Specifications") and locate drive shaft housing over-all bearing preload torque on top line. Locate propeller shaft bearing preload torque on left side column. (Refer to example shaded area on chart, Section 8, "Specifications".) The 2 figures in intersecting block (located on preload chart) are upper and lower limits of drive unit over-all bearing preload torque, as measured from propeller shaft.
3. Tighten gear housing to drive shaft housing nuts evenly to maintain an even gap between housings until bearing preload torque, measured at propeller shaft, is within limits determined from chart. (Figure 13)
4. Measure gap between housings on both sides of drive shaft (Figure 13) and take an average of these readings. Remove gear housing and subtract that amount of shims from under (over-shimmed) bearing cup, then reinstall cup.
5. Install trim tab allen head screw (if removed) in hole provided in gear housing.
6. Install "O" ring around lower drive shaft bearing cup on drive shaft housing and "O" ring in groove around oil recirculating passage in gear housing.
7. Connect gear housing to drive shaft housing with 7 nuts. Tighten evenly. Recheck overall preload.
8. Install one allen head screw (located in trim tab cavity).
9. Install trim tab and trim tab screw access hole plug. Replace propeller and propeller components.

Figure 13. Installing Gear Housing

CAUTION: Propeller nut must be locked with tab washer to retain propeller.

10. Fill drive unit with fresh Super-Duty Gear Lubricant (C-92-75580 tube, C-92-75601 can, C-92-75603 37 lb. pail, C-92-75604 120-lb. drum), as illustrated in "Stern Drive Unit Installation", Section 2.

DRIVE SHAFT HOUSING

For repair instructions on drive shaft housing, refer to "Drive Shaft Housing Assembly", Section 6B - MerCruiser II-TR Drive Unit.

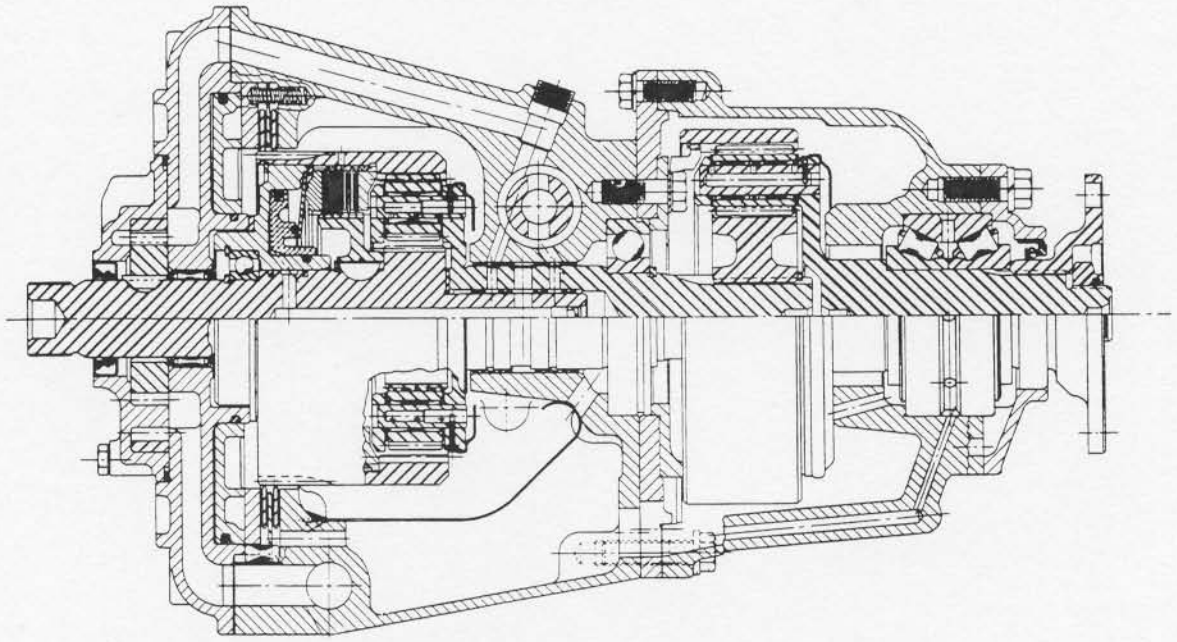
GIMBAL HOUSING

For repair instructions on gimbal housing, refer to "Gimbal Housing", Section 6B - MerCruiser II-TR Drive Unit.

SECTION 6 - DRIVE SYSTEMS

mercruiser

PART D - DIRECT DRIVE TRANSMISSION



MERCURY MARINE

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All "J" (Special) Tools Listed Herein May Be Purchased from:

Kent-Moore, Inc.
28635 Mound Road
Warren, Michigan 48089

(Refer to Page 6D-19.)

STERN DRIVE DIRECT DRIVE TRANSMISSION SERIES 71 and 72

DESCRIPTION

NOTICE: Refer to Last Page in This Part for Special Tools.

The transmission consists of a planetary gear set, a forward clutch, a reverse clutch, an oil pump and a pressure regulator and rotary control valve. All are contained in a cast iron housing (along with necessary shafts and connectors) to provide forward, reverse and neutral operation.

A direct drive ratio is used for all forward operation. In reverse, speed of the output shaft is equal to input shaft speed, but in the opposite direction. Helical gearing is used to provide operation more quiet than can be obtained with spur gearing.

Shifting is accomplished by fore and aft movement of the shift lever. This movement rotates control valve and directs oil under controlled pressure to required channels.

Oil pressure is provided by the crescent type pump and drive gear which is keyed to the drive shaft. Pump operates at transmission input speed to provide screened oil to the pressure regulator.

From the regulator valve, oil is directed through proper circuits to bushings and anti-friction bearings which require lubrication. A flow of lubricant is present at the required parts whenever the front pump is turning, and it should be noted that supply is positive in forward, neutral and reverse conditions.

The unit has seals to prevent escape of oil.

Both input and output shafts are coaxial, with input shaft splined for installation of a drive damper, and output shaft splined for connecting to the stern drive unit.

PRECAUTIONS

1. Oil cooler must be properly connected to transmission before engine is cranked or started. Failure to properly connect oil cooler will cause forward clutch piston to blow out from over-pressurization.
2. Change oil and clean oil screen once each season.
3. Check oil level at operating temperature.
4. Check oil level immediately after engine is shut off.
5. Use clean containers for handling transmission fluid.
6. Fill transmission prior to starting engine.
7. Use recommended automatic transmission fluids Type "A", Suffix "A" or new Dexron fluid.
8. Flush cooler and cooler lines after a transmission failure and prior to installing a new or rebuilt transmission.
9. Check engine alignment each time a transmission is replaced in boat.
10. Check shift linkage adjustment to insure that transmission shift lever is being positioned so that spring-loaded ball enters chamfered hole inside of shift lever in each selected position.
11. Check oil pressure and temperature when transmission functions indicate that a problem exists.
12. Always check pump hand of rotation prior to assembling transmission to engine to ensure that pump is properly indexed for engine rotation.
13. Except in emergency, never shift at engine speeds above 1000 RPM.
14. Never remove oil cooler lines or use smaller than recommended 13/32" (10.3mm) diameter cooler lines when operating transmission.
15. Do not permit propeller shaft to rotate when transmission is inoperative. Propeller shaft rotation could be caused by towing, sailing or operation of second engine which could move the boat through the water and cause propeller to "windmill".
16. Ribbon dope (a thread sealant) must be used on hydraulic connections when hydraulic lines are installed, to prevent hydraulic fluid from leaking.

LUBRICATION RECOMMENDATIONS

The properties of the oil used in the transmission are extremely important to the proper function of the hydraulic system. Therefore, it is necessary that the recommended oil, automatic transmission fluid (ATF), Type "A", Suffix "A", be used.

PROCEDURE for FILLING TRANSMISSION with OIL

When filling transmission, add oil until it reaches full mark on dipstick. Quantity of oil depends upon angle of installation, but information to serve as a guide on possible amount needed may be found in chart following. Unit should be turned over at engine idle speed for a short time in order to fill all circuits, including cooler and cooler piping.

NOTE: Be sure that cooler is properly installed and that transmission contains oil before cranking or starting engine.

PROCEDURE for CHECKING OIL LEVEL

Oil level should be checked immediately after stopping engine, and sufficient oil added to again bring transmission oil level to full mark on dipstick assembly. Dipstick assembly need not be threaded into case to determine oil level. Merely insert into case until cap or plug rests on surface surrounding oil filler hole.

Transmission should be checked periodically to assure proper oil level, and oil should be added if necessary.

CHANGING OIL

It is recommended that transmission oil be changed once each season. After draining oil from unit, thoroughly clean the removable oil screen before refilling transmission with recommended oil (ATF), Type "A", Suffix "A".

NOTE: Oil capacity does not include capacity needed for transmission cooler and oil lines, which may require an amount greater than in table, below.

OIL CAPACITY

Transmission Model	Transmission Oil Capacity (Quarts)	
	Level	15° Inclined
AS 1-71C	1.8	1.3
AS 1-72C	2.1	1.7

TROUBLESHOOTING

Refer to Section 10, "Troubleshooting".

71 and 72 SERIES TRANSMISSION (STERN DRIVE)

1 - Transmission Assembly
2 - Bushing Kit
3 - Breather
4 - Spring, poppet
5 - Ball, detent
6 - Dipstick
7 - Spring and Valve Assembly
8 - "O" Ring
9 - Cover, valve
10 - Gasket
11 - Screw
12 - Lockwasher
13 - Strainer, oil
14 - Tube, oil strainer
15 - Bushing
16 - Baffle, oil
17 - Gasket
18 - Ring, snap
19 - Washer, thrust
20 - Pinion Gear and Shaft Assembly
21 - Washer, thrust
22 - Key
23 - Drive Gear and Shaft Assembly
24 - Gear, forward clutch
25 - Ring, snap
26 - Key
27 - Ring, sealing
28 - Gear, ring
29 - Plate, pressure
30 - Plate, clutch (outer) bronze
31 - Plate, clutch (inner) steel
32 - Plate, pressure
33 - Spring, clutch plates
34 - Ring, sealing
35 - Ring, forward clutch piston
36 - Piston, forward clutch
37 - "O" Ring
38 - Cylinder, forward clutch
39 - Ball Bearing
40 - Ring, snap - ball bearing retainer
41 - Ring, snap - ball bearing retainer
42 - Washer, thrust
43 - Ring, snap
44 - Plate, reverse clutch
45 - Plate, reverse clutch
46 - Pin, dowel
47 - Spring
48 - Plate, pressure
49 - Ring, sealing
50 - Piston, reverse clutch
51 - "O" Ring
52 - Adaptor
53 - Roller Bearing
54 - Screw
55 - Gasket
56 - Front Pump Assembly
57 - Oil Seal
58 - Screw

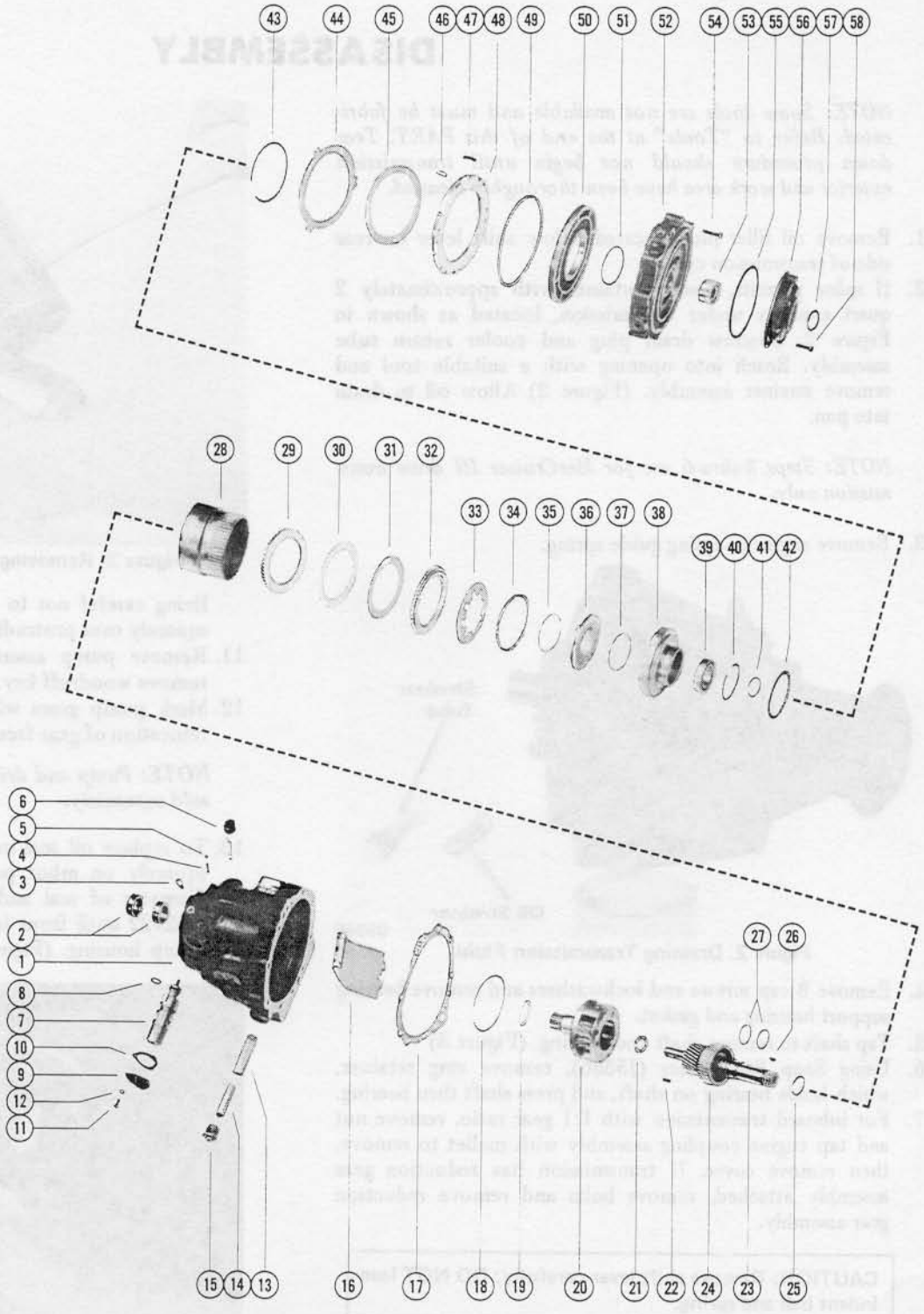

Figure 1. Transmission, Exploded View

REMOVAL

NOTE: Engine must be removed to remove transmission. Refer to "Removal-Installation-Alignment" Section 2.

1. Remove shift linkage and oil lines.
2. Remove rear engine mounts from transmission.
3. Remove 6 bolts which attach transmission to flywheel housing.
4. Remove transmission.

DISASSEMBLY

NOTE: Some tools are not available and must be fabricated. Refer to "Tools" at the end of this PART. Teardown procedure should not begin until transmission exterior and work area have been thoroughly cleaned.

1. Remove oil filler plug, located below shift lever on rear side of transmission case.
2. If space permits, place container with approximately 2 quart capacity under transmission, located as shown in Figure 2. Unscrew drain plug and cooler return tube assembly. Reach into opening with a suitable tool and remove strainer assembly. (Figure 2) Allow oil to drain into pan.

NOTE: Steps 3-thru-6 are for MerCruiser III drive transmission only.

3. Remove engine coupling guide spring.

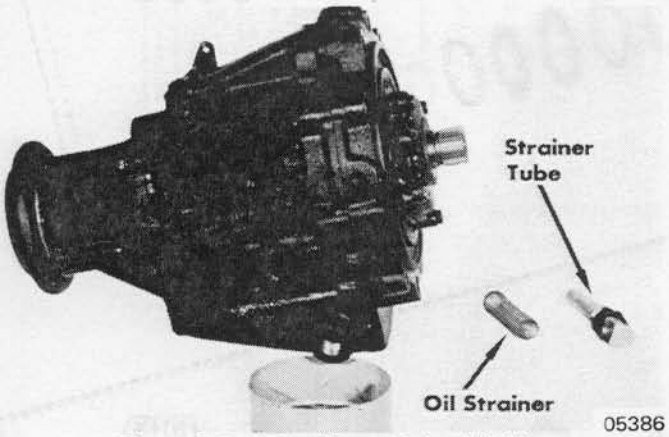

Figure 2. Draining Transmission Fluid

4. Remove 8 cap screws and lockwashers and remove bearing support housing and gasket.
5. Tap shaft to remove shaft and bearing. (Figure 3)
6. Using Snap Ring Pliers (J5586), remove ring retainer, which holds bearing on shaft, and press shaft thru bearing.
7. For inboard transmission with 1:1 gear ratio, remove nut and tap engine coupling assembly with mallet to remove, then remove cover. If transmission has reduction gear assembly attached, remove bolts and remove reduction gear assembly.

CAUTION: Remove shift lever carefully; DO NOT lose indent ball and spring.

8. Remove nut, lockwasher and flat washer from shift lever and remove shift lever.
9. Remove 3 screws and lockwashers, valve cover and gasket. Tap out valve assembly. (Figure 4)
10. Note location of arrow on pump. Remove 4 cap screws from oil pump. Apply tape around input shaft splines.

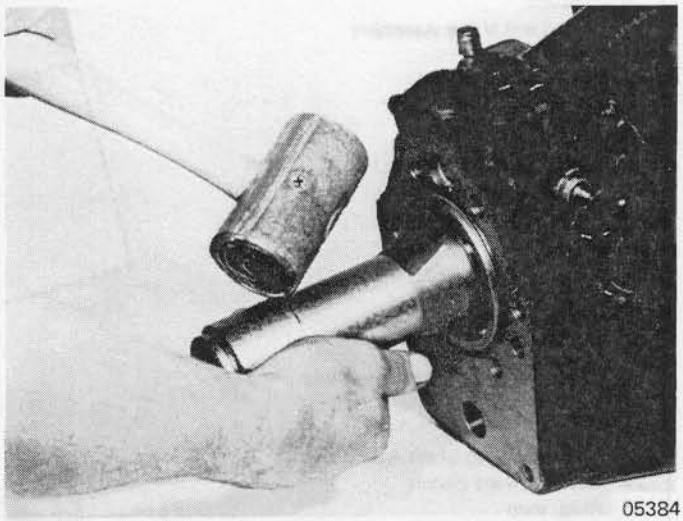

Figure 3. Removing Bearing and Shaft from Case

Being careful not to damage seal lip, lift pump assembly squarely over protruding input shaft.

11. Remove pump assembly and front pump gasket, then remove woodruff key. (Figure 5)
12. Mark pump gears with marking pen to identify proper relocation of gear faces during reassembly.

NOTE: Pump and drive gear are a matched set and are not sold separately.

13. To replace oil seal in pump housing, place pump housing squarely on arbor press table. Apply Loctite to outside diameter of seal and press seal into housing with Tool J-22922 until front face of seal is flush with front face of pump housing. (Figure 6) Wipe away any excess Loctite.

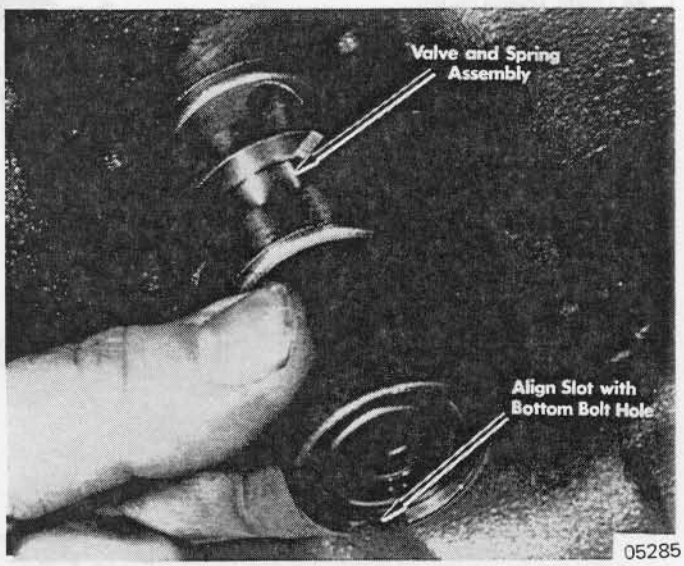

Figure 4. Valve Removal

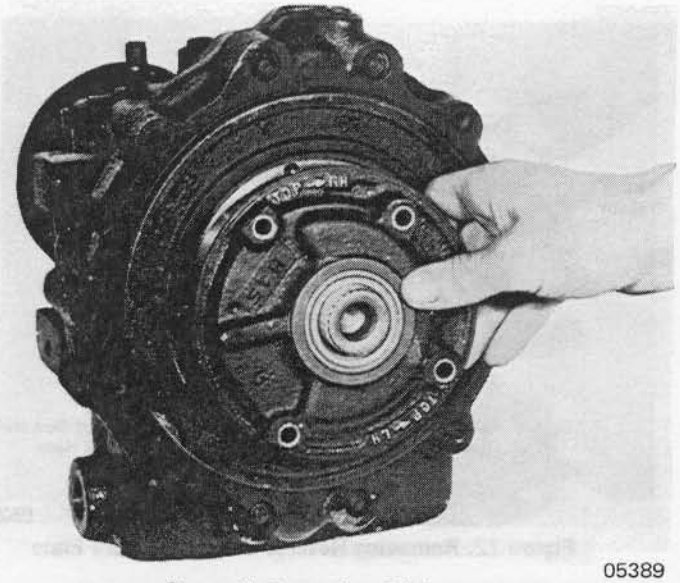

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Figure 5. Removing Oil Pump

CAUTION: Reverse clutch pressure plate may stick momentarily to reverse clutch piston. To avoid damage, prevent pressure plate from dropping.

14. Remove 4 cap screws (12 point head). (Figure 7) Lift adaptor and reverse clutch piston. (Figure 8) If necessary, tap adaptor with a soft hammer to remove.

15. Force compressed air into reverse clutch cavity while holding piston, as shown in Figure 9, and piston will pop out of reverse clutch cavity.

16. Remove sealing rings as shown in Figures 10 and 11.

17. Check needle bearing in adaptor for wear. Replace if worn.

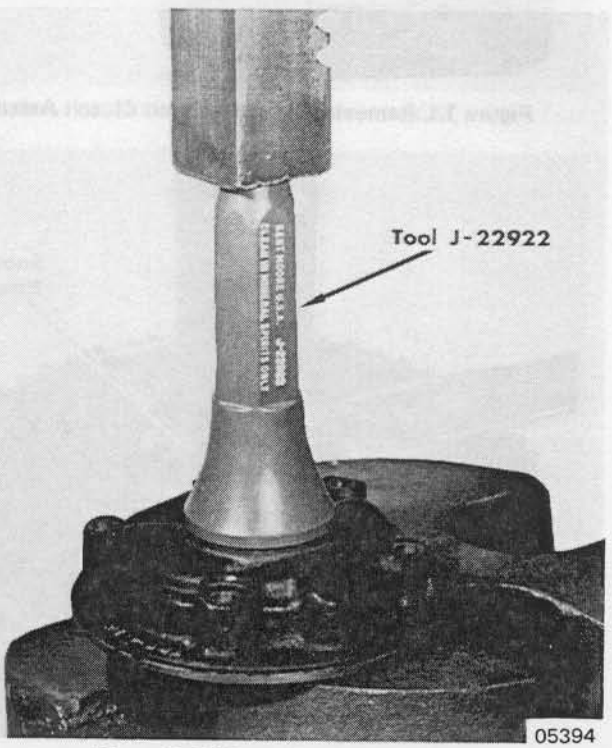

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Figure 6. Oil Seal Installation

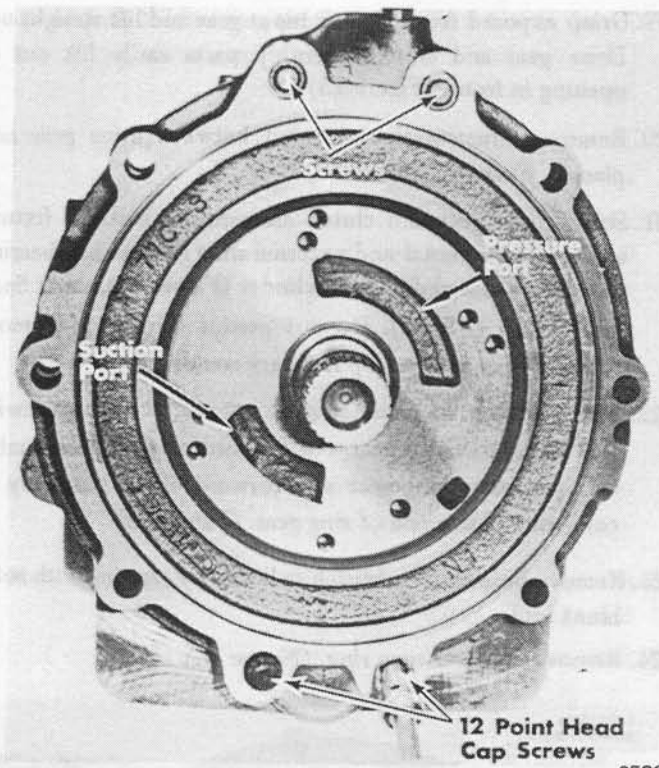

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Figure 7. Removing Adaptor

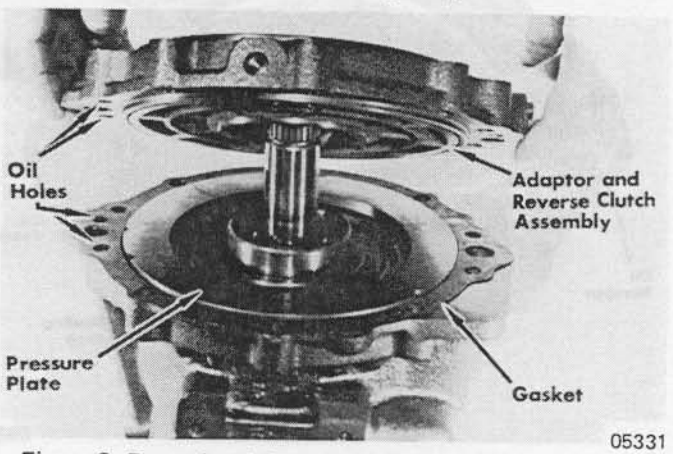

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Figure 8. Removing Adaptor and Reverse Clutch Assembly

18. Remove thrust washer (Item 42 in Figure 1), clutch pressure plate (48), 12 pressure plate springs (47) and 3 dowel pins (46) and reverse clutch pressure plates. (Figure 12)

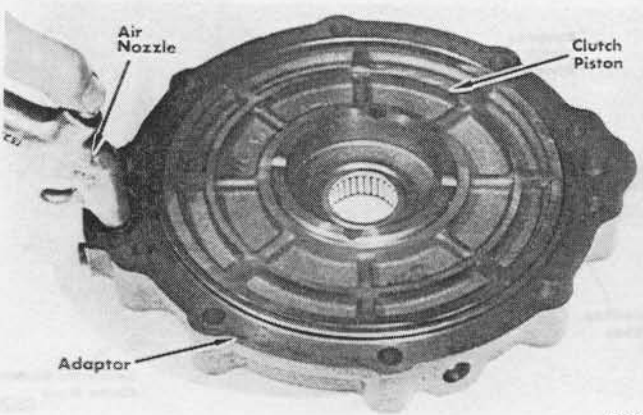

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Figure 9. Disassembling Reverse Clutch Piston

19. Grasp exposed front end of input gear and lift straight up. Drive gear and clutch assembly parts easily lift out of opening in front. (Figure 13)

20. Remove thrust washer, located between drive gear and planetary carrier. (Figure 13)

21. Stand drive gear and clutch assembly in suitable fixture and remove internal and external snap rings at ball bearing from drive gear and clutch cylinder (Figure 14), using Snap Ring Pliers (J-5586). Do not permit drive gear to move forward after above snap rings are removed.

22. While holding ring gear, tap front end of drive gear with soft hammer. Drive gear and forward clutch hub assembly will pass thru ring gear and forward clutch assembly to come out of rear end of ring gear. (Figure 15)

23. Remove bearing from clutch cylinder by tapping with soft, blunt tool.

24. Remove ring gear snap ring. (Figure 16)

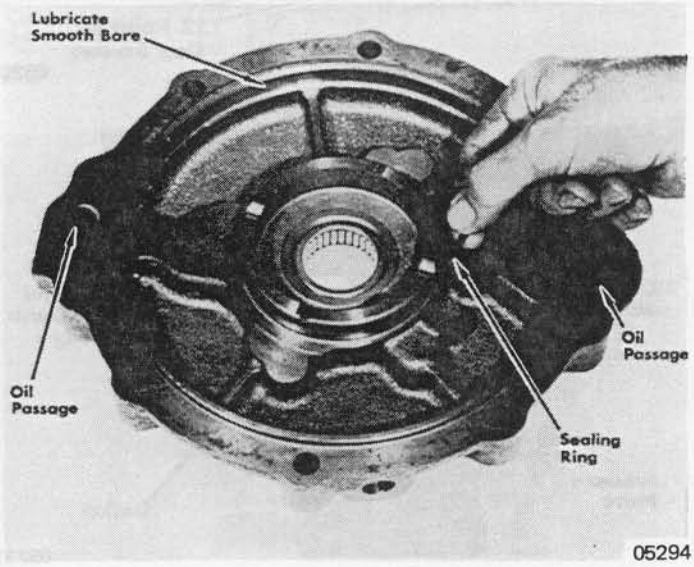

Figure 10. Removing Sealing Ring

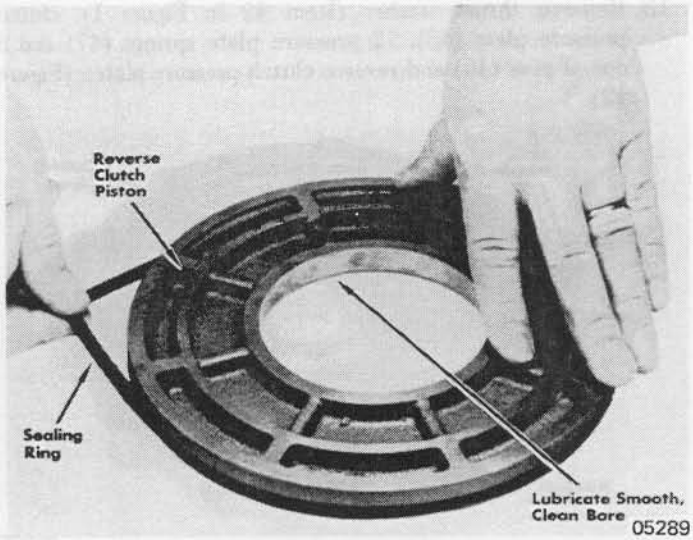

Figure 11. Removing Outer Sealing Ring

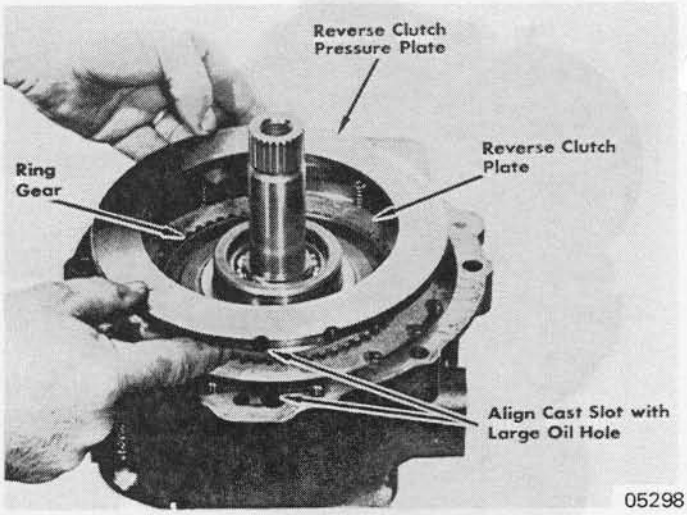

Figure 12. Removing Reverse Clutch Pressure Plate

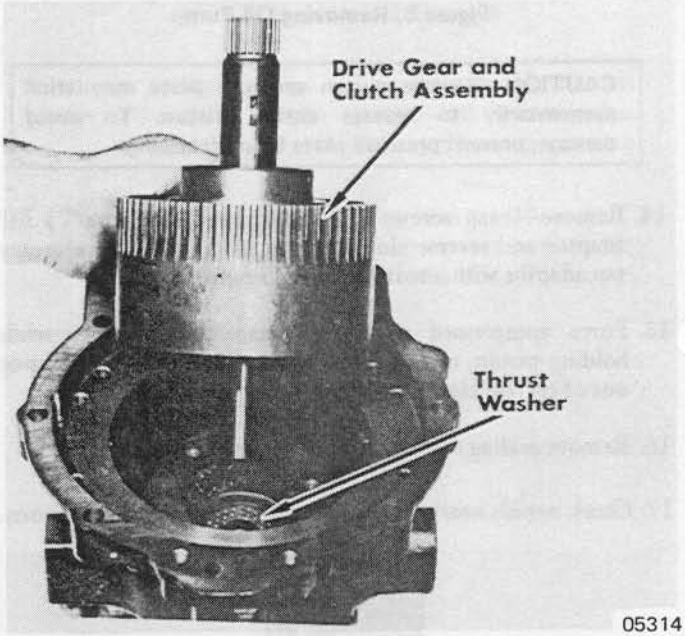

Figure 13. Removing Drive Gear and Clutch Assembly

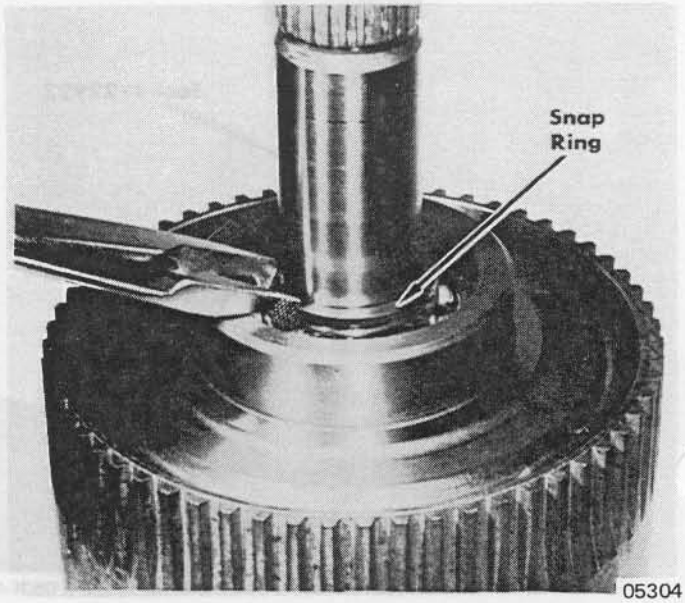

Figure 14. Removing Snap Ring

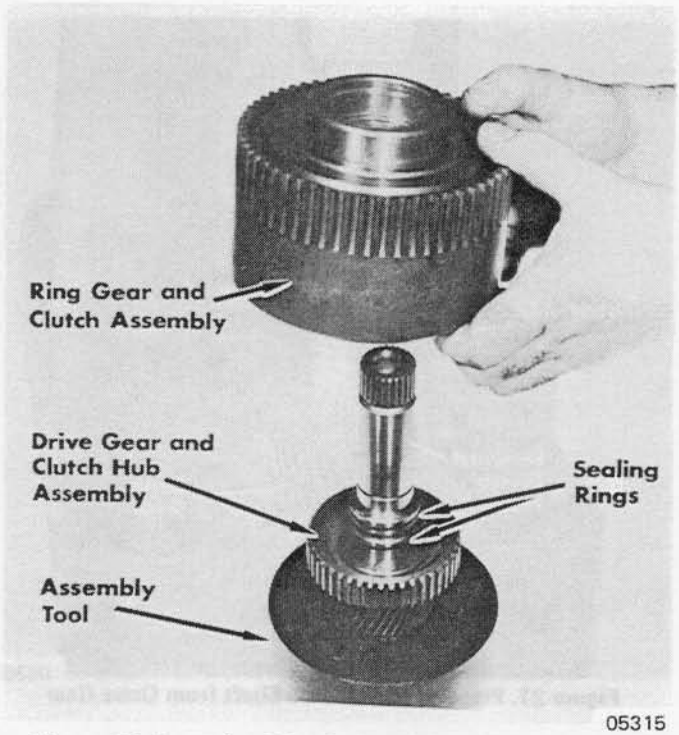

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Figure 15. Removing Ring Gear and Clutch Assembly

25. While holding ring gear, tap with soft, blunt tool on exposed face of forward clutch cylinder inside of ring gear. Forward clutch cylinder will move forward to disassemble out of front of ring gear. After removing clutch spring and clutch spring snap ring, all parts of forward clutch can be disassembled.

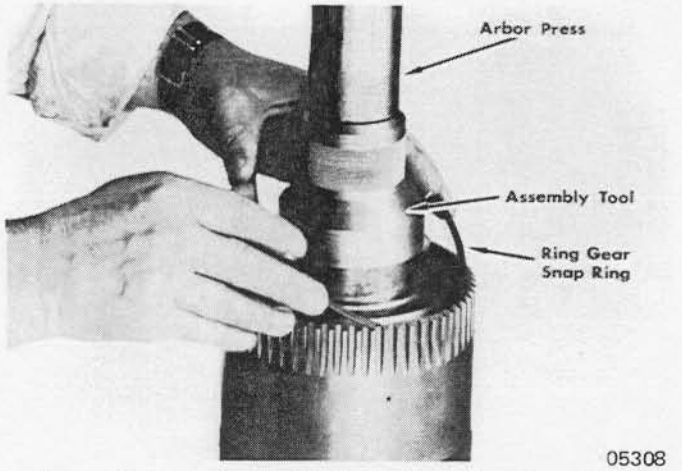

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Figure 16. Removing and Installing Ring Gear Snap Ring

26. Piston can be removed from forward clutch cylinder (Figure 17) by applying compressed air to clutch cavity through one of 3 holes in inside diameter of forward clutch cylinder, while other holes are blocked.
27. Remove forward clutch small sealing rings, as shown in Figure 18.
28. Remove forward clutch large sealing ring. (Figure 19)
29. Using Snap Ring Pliers (J-5586), remove snap ring from drive gear. (Figure 20)

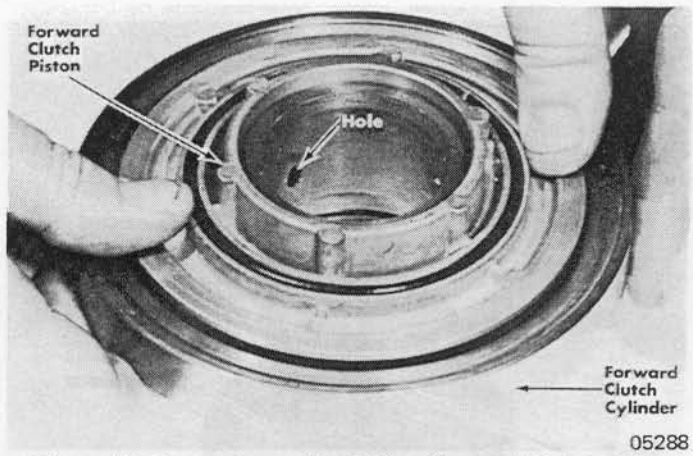

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Figure 17. Removing and Installing Forward Clutch Piston

30. If drive gear must be replaced, press clutch hub shaft out of drive gear. (Figure 21)
31. Remove pinion cage and output shaft by lifting out of transmission housing.
32. Remove thrust washer from pinion cage and output shaft.
33. Remove oil baffle from transmission housing by pressing down on baffle and pulling baffle out.

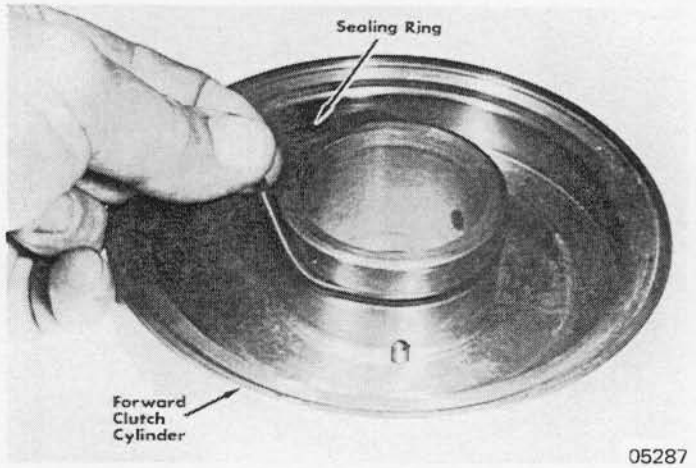

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Figure 18. Removing Forward Clutch Cylinder Sealing Ring

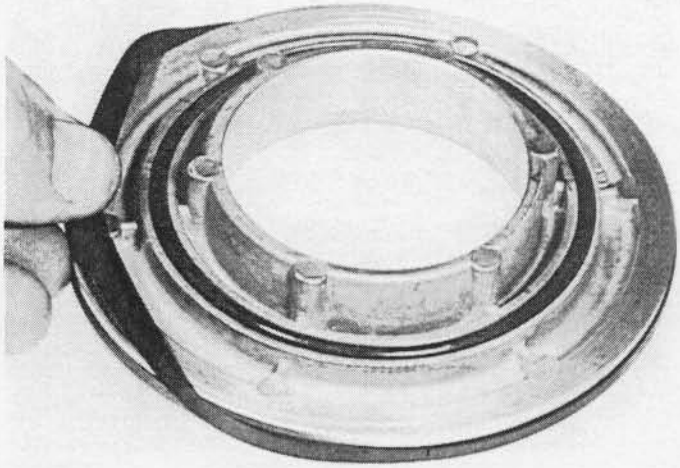

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Figure 19. Removing Forward Clutch Piston Sealing Ring

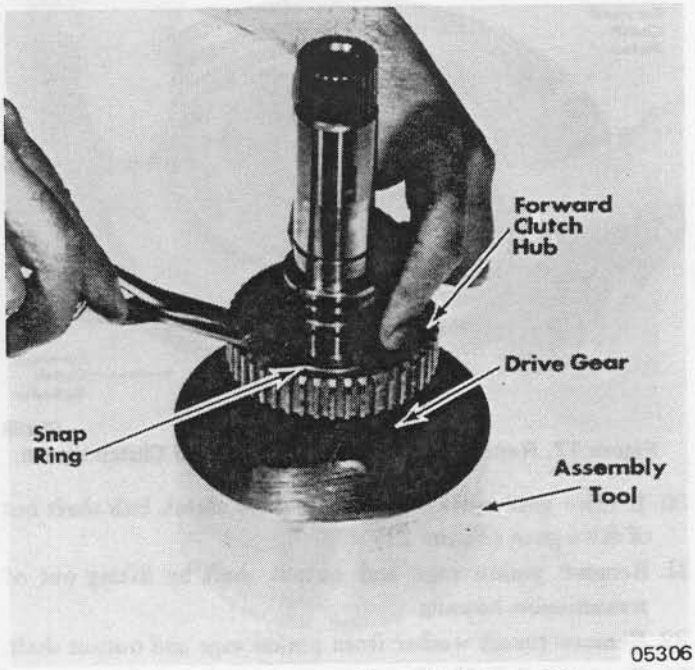

Figure 20. Removing Clutch Hub Snap Ring

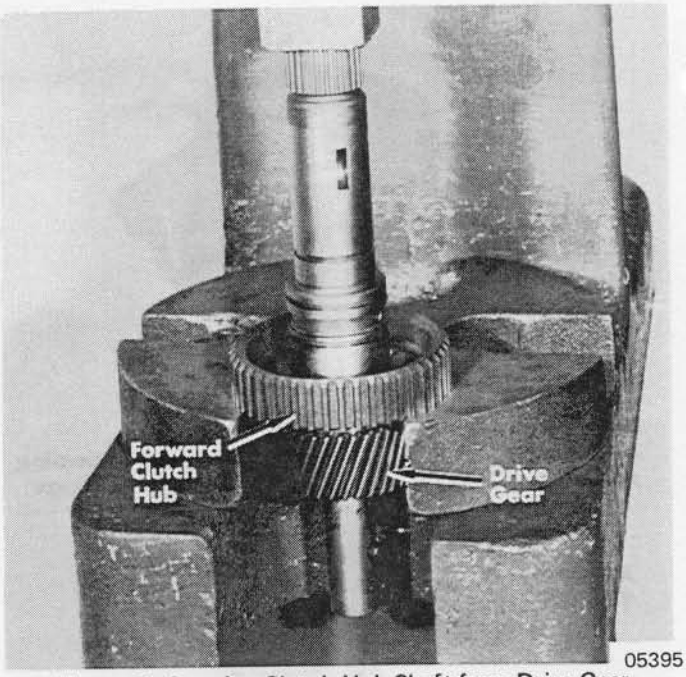

Figure 21. Pressing Clutch Hub Shaft from Drive Gear

TRANSMISSION CASE BUSHING

1. Check bushings for fit and wear. Replace bushings as required.
2. Remove bushings with Tools J-8466 and J-7079-2. (Figure 1)
3. Check bore size. Bore should be 1.989" to 1.990". If bore exceeds this dimension, replace housing.
4. Coat inside of bore with Loctite Retaining Compound 35 (C-92-58254A1).

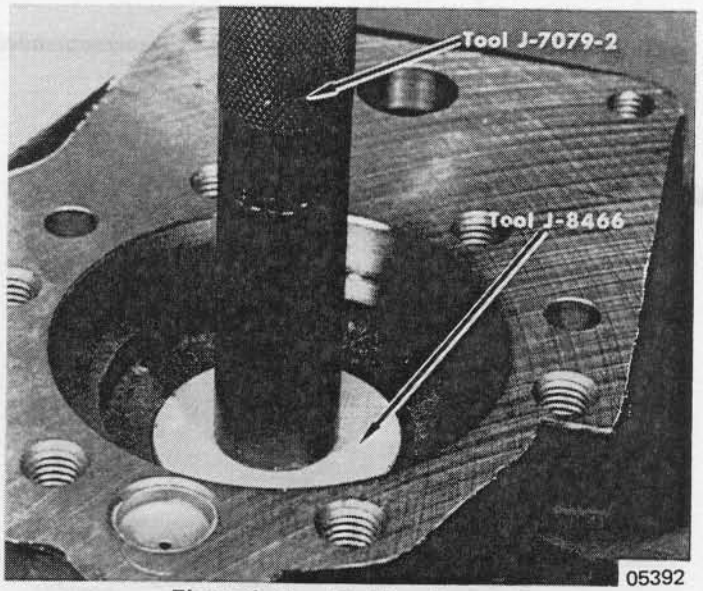

Figure 1. Case Bushing Removal

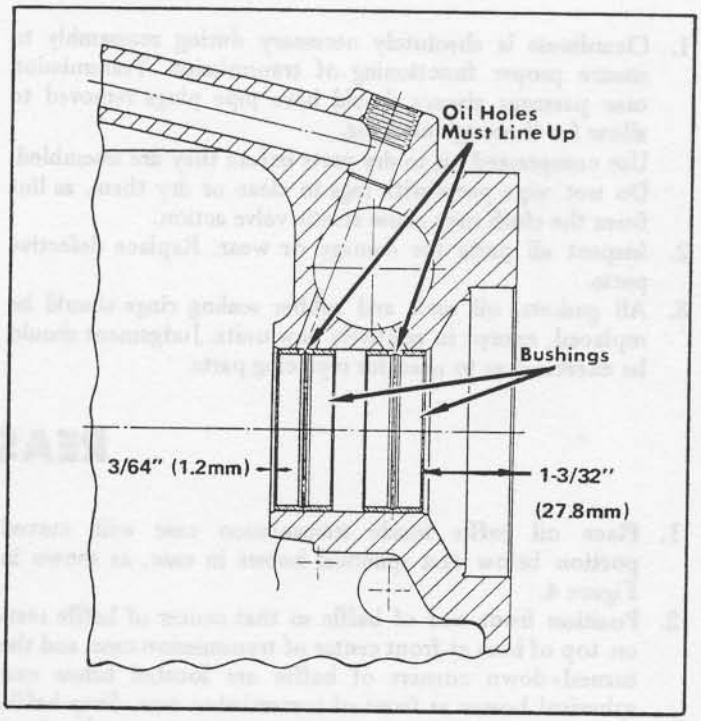

Figure 2. Case Bushing Installation

5. Install new bushing from Bushing Kit (B-23-56572) with Tools J-8466 and J-7079-2. Oil holes in bushings must line up with oil holes in case. Bushings are pressed in from their respective ends.

OUTPUT SHAFT BUSHING

1. Check bushings for fit and wear. Replace bushings as required.
2. Press bushings from output shaft with Tool C-91-58868. (Figure 3)

   NOTE: Oil holes in bushings must line up with oil holes in shaft. (Step 3)

3. Coat inside of bore with Loctite Retaining Compound 35 (C-92-58254A1) and install new bushings from 2 Bushing Kits (B-23-56562) with Tool C-91-58868. Discard extra bushing.

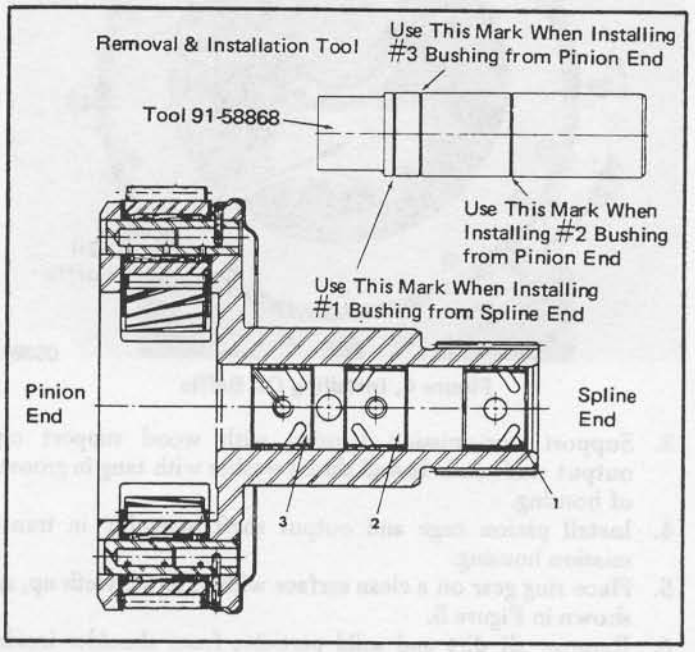

Figure 3. Shaft Bushing Installation

CLEANING and INSPECTION

1. Cleanliness is absolutely necessary during reassembly to ensure proper functioning of transmission. Transmission case passages always should have pipe plugs removed to allow for thorough cleaning.
   Use compressed air to dry parts before they are assembled. Do not wipe parts with rags to clean or dry them, as lint from the cloth may cause erratic valve action.
2. Inspect all parts for damage or wear. Replace defective parts.
3. All gaskets, oil seals and rubber sealing rings should be replaced, except in relatively new units. Judgement should be exercised as to need for replacing parts.
4. Oil seals and bearings are best installed by using an arbor press, suitable fixtures and tools to properly align parts being assembled. Using a hammer to position seals and bearings can severely damage parts.
5. Use automatic transmission fluid Type "A", Suffix "A" to lubricate parts as they are assembled. Petroleum jelly may be used on gaskets or other parts that must be held in position during assembly. All rubber parts will slide more freely if lubricated.
6. Tighten all bolts and screws evenly to recommended torque shown in Section 8.

REASSEMBLY

1. Place oil baffle inside transmission case with curved portion below cast spherical bosses in case, as shown in Figure 4.
2. Position front end of baffle so that center of baffle rests on top of boss at front center of transmission case, and the turned-down corners of baffle are located below cast spherical bosses at front of transmission case. Snap baffle into position by lifting up on curved portion so that the 2 large holes are located firmly on spherical bosses at rear of transmission case.

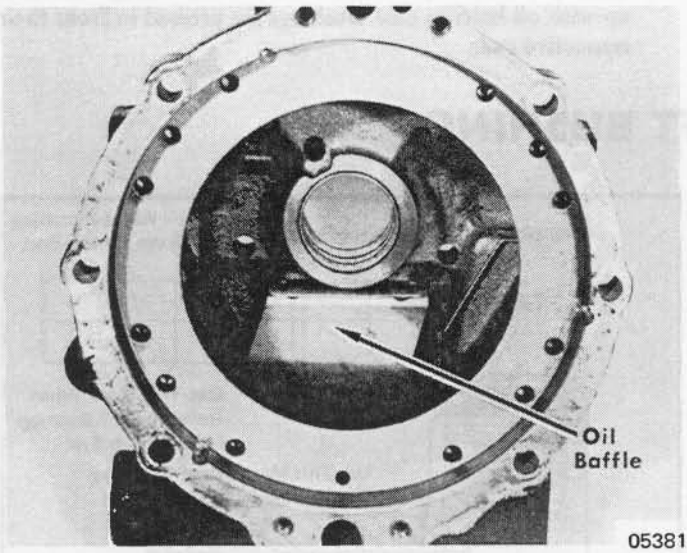

Figure 4. Installing Oil Baffle

3. Support transmission housing with wood support on output shaft end. Install thrust washer with tang in groove of housing.
4. Install pinion cage and output shaft assembly in transmission housing.
5. Place ring gear on a clean surface with external teeth up, as shown in Figure 5.
6. Remove all dirt and solid particles from shoulder inside gear formed by top of internal helical gear. (Figure 5)
7. With smoothly ground face in upward position, install clutch pressure plate (rear) in ring gear as shown in Figure 5. Assembly is complete when clutch pressure plate is firmly and squarely seated on shoulder at bottom of internal splines.

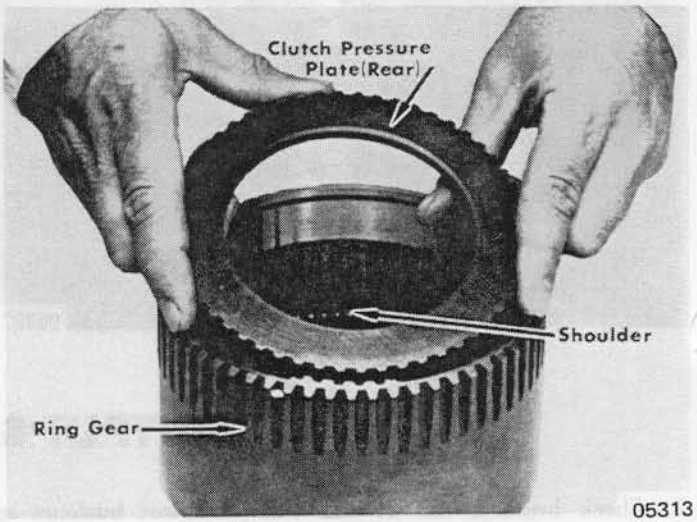

Figure 5. Installing Clutch Pressure Plate (Rear)

8. For Model 71C, lubricate 5 clutch inner plates and 4 outer clutch plates, arrange and assemble as shown in Figure 6. For Model 72C, lubricate 7 clutch inner plates and 6 center clutch plates.

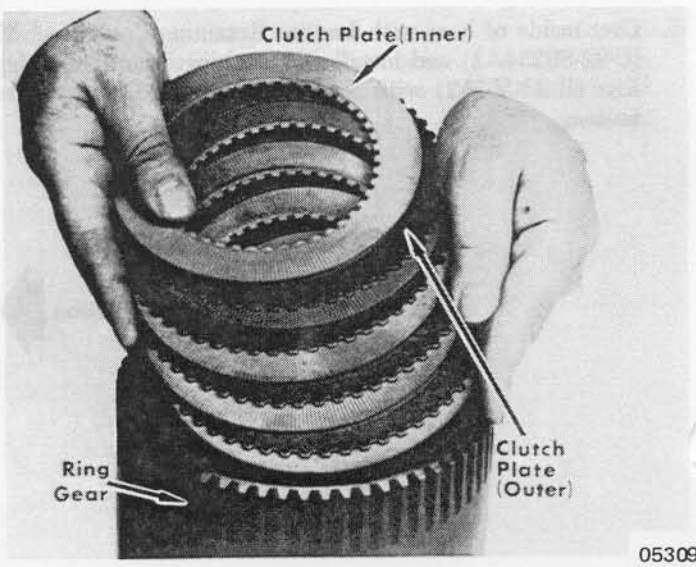

Figure 6. Installing Forward Clutch Plates

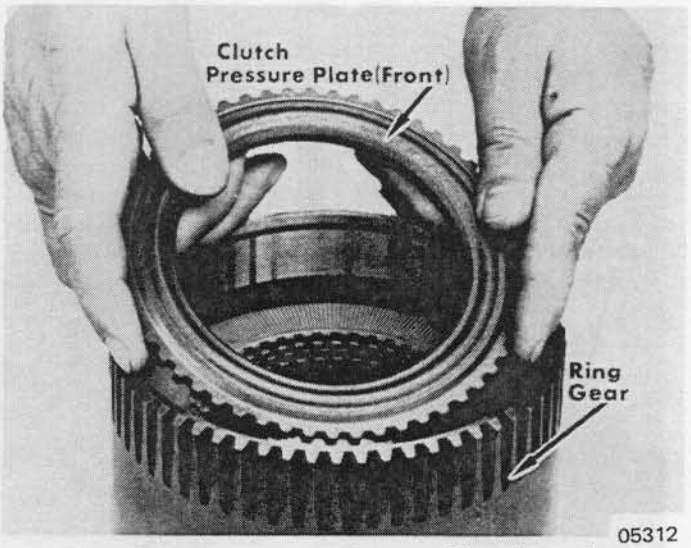

Figure 7. Installing Clutch Pressure Plate (Front)

9. Install clutch pressure plate (front) with flat face down in contact with clutch plate, as shown in Figure 7.
10. Install clutch spring snap ring. (Figure 8) Assembly is complete when snap ring is squarely and firmly seated on internal shoulder provided on top of internal splines.

CAUTION: Use proper snap ring. Clutch spring snap ring is .090" to .093" (2.29mm to 2.36mm) thick and has a free diameter of 5-19/32" (14.2cm) ± 1/16" (1.6mm).

11. With concave side of clutch spring down, install in ring gear as shown in Figure 9. Assembly is complete when clutch spring is seated firmly and squarely on clutch snap ring.
12. Assemble clutch spring bearing ring and a lubricated clutch sealing ring on forward clutch piston as shown in Figure 19 in "Disassembly", preceding. Inspect inside diameter of forward clutch piston which contacts sealing ring. Remove all burrs or scratches and lubricate before assembly.
13. Install a well-lubricated sealing ring in forward clutch cylinder. (Figure 18 in "Disassembly") Lubricate entire forward clutch cylinder before continuing assembly.

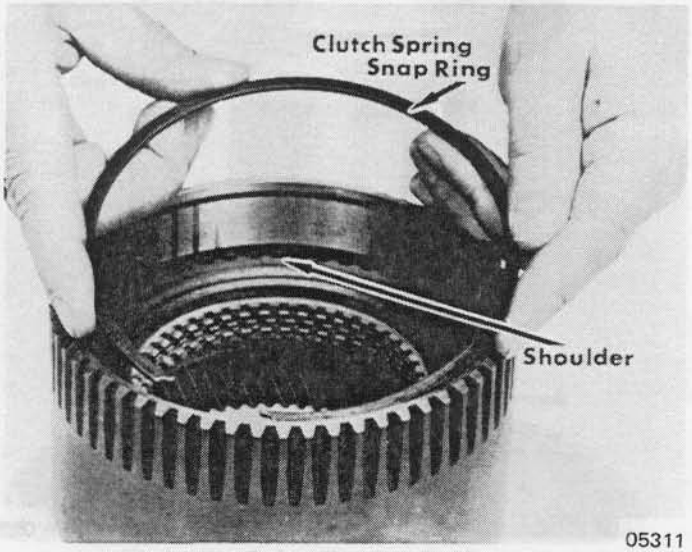

Figure 8. Installing Clutch Spring Snap Ring

14. After aligning assembled forward clutch piston squarely on assembled forward clutch cylinder, press clutch piston into forward clutch cylinder. (Figure 10) This is a hand assembly and should not require pounding by hammer or pressing on arbor press. Assembly is complete when piston "bottoms" in forward clutch cylinder.
15. Place clutch plate assembly on a suitable support which has been placed on an arbor press. (Figure 11) Center clutch spring in ring gear.
16. Place clutch and shaft assembly into open top of clutch plate assembly. (Figure 11) Place a suitable assembly tool squarely on top of forward clutch cylinder and press down with arbor press until forward clutch cylinder is firmly seated on snap ring, and groove for snap ring is fully exposed. Check by looking into rear of ring gear to be sure that clutch bearing ring is properly assembled on forward clutch piston.

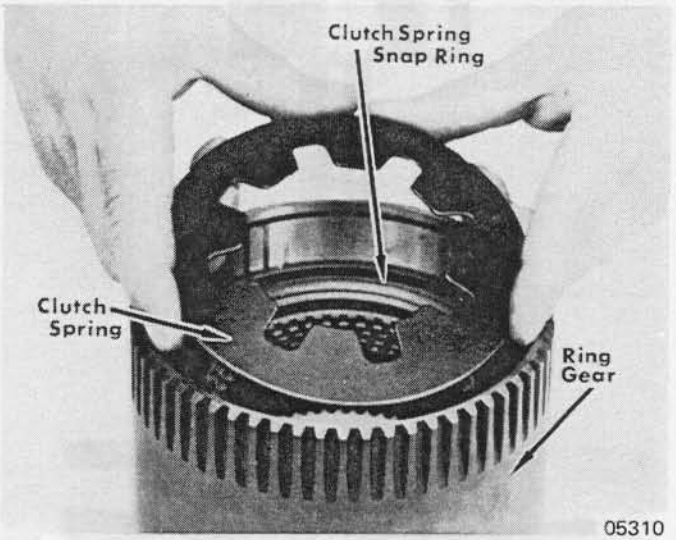

Figure 9. Installing Clutch Spring

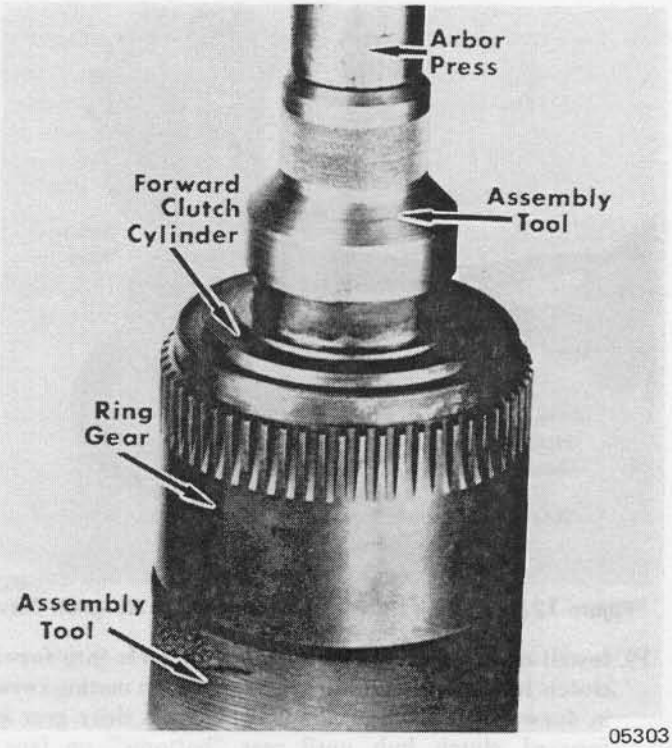

Figure 10. Pressing Forward Clutch Cylinder into Ring Gear

17. While maintaining load from arbor press, assemble ring gear snap ring. (Figure 16 in "Disassembly") Tap ring while in place to ensure full seating of ring in groove.

CAUTION: Use proper snap ring. Ring gear snap ring is .074" to .078" (1.88mm to 1.98mm) thick and has a free diameter of 5-7/8" (14.9cm) ± 1/16" (1.6mm).

18. Place forward clutch hub on a suitable support placed on an arbor press in position shown in Figure 11. Assemble woodruff key in keyway provided on drive gear. (Figure 11) Lubricate outside diameter of drive gear on area which presses into forward clutch hub.

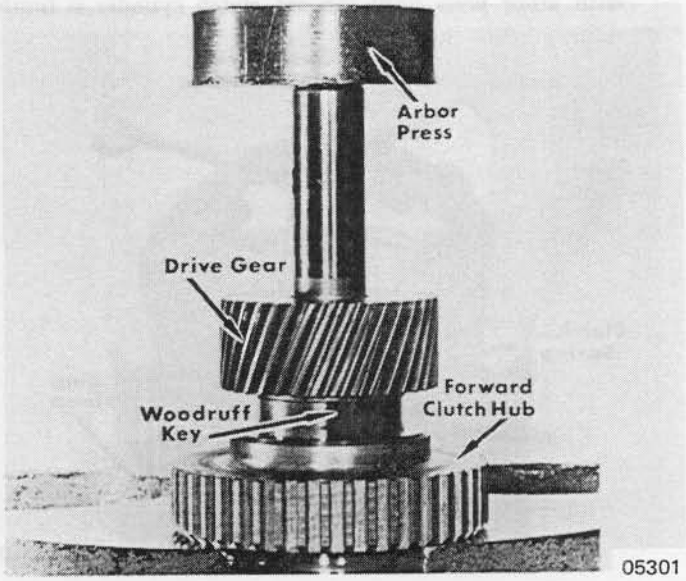

Figure 11. Pressing Drive Gear into Forward Clutch Hub

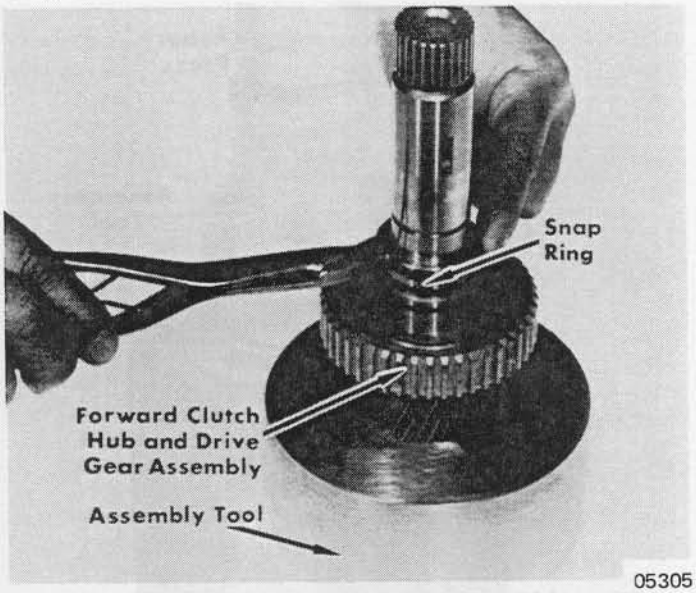

Figure 12. Installing Forward Clutch Sealing Rings on Drive Gear

19. Install drive gear and woodruff key squarely into forward clutch hub, being careful to align key with mating keyway in forward clutch hub. (Figure 11) Press drive gear into forward clutch hub until gear "bottoms" on face of forward clutch hub, and groove for snap ring is fully uncovered.
20. Invert forward clutch assembly and install snap ring in groove provided. (Figure 11) Tap ring after assembly with suitable tool to ensure full seating in groove.

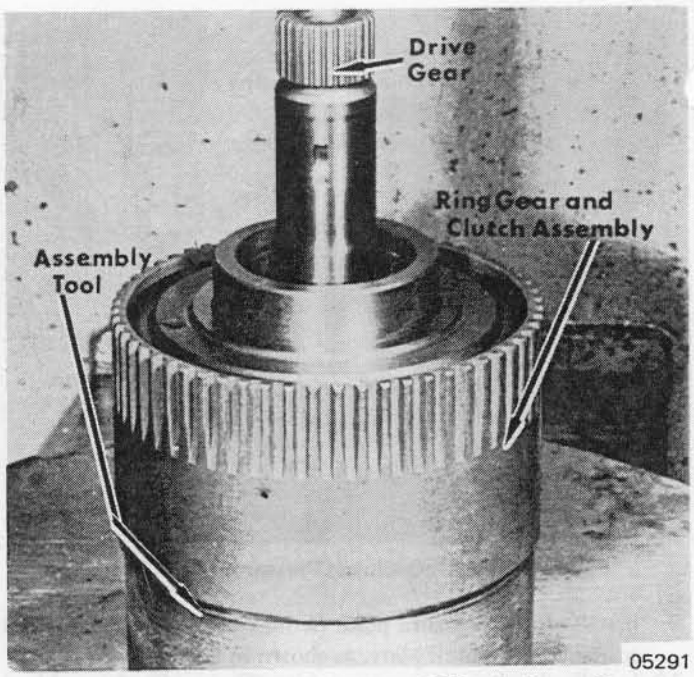

Figure 13. Assembling Ring Gear and Clutch Assembly on Drive Gear

21. Install 2 forward clutch sealing rings in grooves provided on drive gear. (Figure 12) After installing rings in groove, hook ends and turn rings to ensure freedom of rotation.
22. With drive gear and clutch hub in assembly tool as shown in Figures 11 and 12, place ring gear and forward clutch assembly over drive gear. (Figure 15 in "Disassembly")
23. Lower ring gear and clutch assembly until internal teeth of clutch plates begin to engage teeth on forward clutch hub. Rotate ring gear to align teeth of plates with teeth on clutch hub. DO NOT force ring gear, or teeth will be damaged. When ring gear and clutch are in correct position, rear end of ring gear should be against assembly tool or "flush" with rear thrust face of drive gear. (Figure 13) DO NOT remove drive gear and clutch assembly from assembly tool or move drive gear forward until Steps 24, 25 and 26 are completed. Any movement of drive gear forward will disengage clutch plates from clutch hub and move sealing rings out of position.

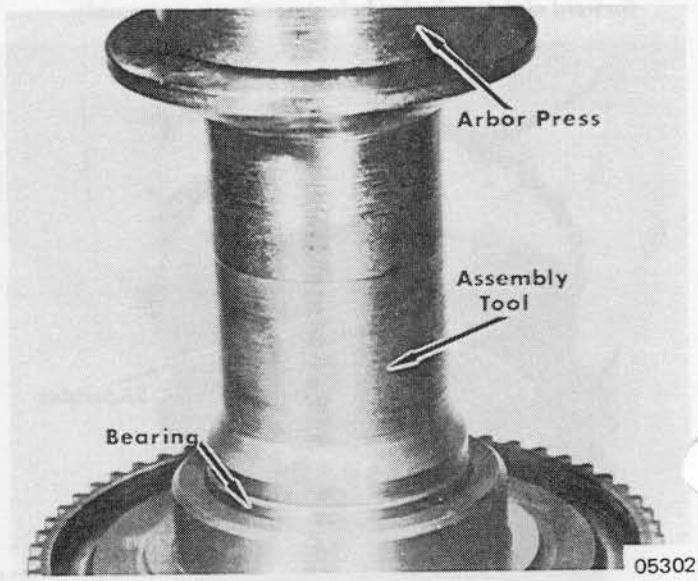

Figure 14. Pressing Clutch Bearing In Place

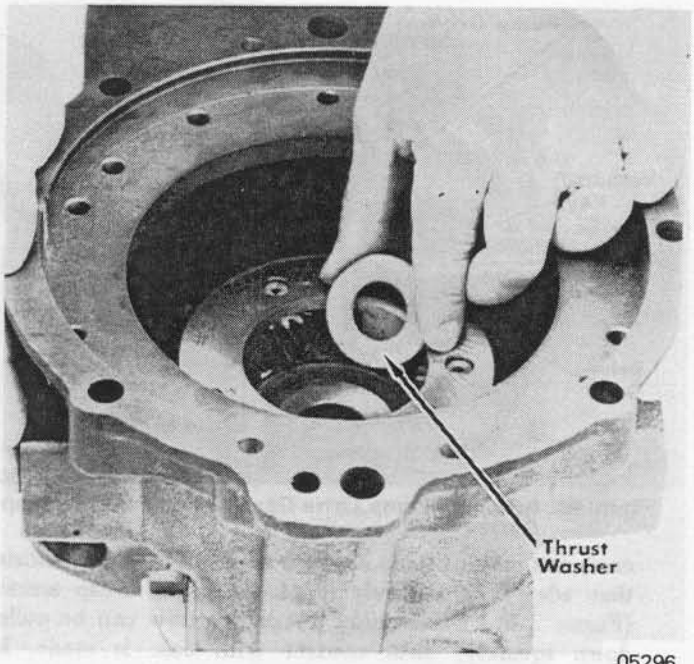

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Figure 15. Installing Thrust Washer

24. Place aligned parts and assembly tool in place on arbor press. Place bearing over protruding drive gear and squarely into bore at front of forward clutch cylinder. Press bearing down with arbor press until bearing is fully seated on shoulder, and snap ring grooves in front of bearing are exposed. (Figure 14)
25. Install external snap ring on drive gear. (Figure 14 in "Disassembly")
26. Using Snap Ring Pliers J-5586, install internal snap ring in clutch cylinder. (Figure 15 in "Disassembly")
27. Place transmission housing on a smooth, clean surface in upright position as indicated in Figure 15. In this position, rear face of rear coupling will provide sufficient base to enable assembly to proceed.
28. Coat drive gear thrust washer with petroleum jelly and assemble into pinion cage and output shaft assembly (Figure 15) Center washer carefully over bore provided for on rear of drive gear.
29. After lubricating rear end of drive gear and checking centered position of thrust washer, install drive gear and clutch assembly into case and pinion cage and output shaft assembly. (Figure 13 in "Disassembly") Exert care and proper centering at this point to prevent damage to bushings when rear diameter of drive gear enters output shaft.
30. Install 12 pressure plate springs in holes provided in reverse clutch cavity. (Figure 16) Holes should be free from dirt, and all springs should be firmly seated.
31. Coat 3 dowel pins with petroleum jelly and assemble them in 3 grooves provided at outside diameter of reverse clutch cavity. (Figure 16) Assembly is complete when dowel pin is firmly seated on end and into groove, as far as groove contour will permit.
32. Install reverse clutch plates (2 bronze and one steel for 71C Series transmission and 3 bronze and 2 steel for 72C Series) over exposed splined teeth of ring gear. Clutch plate must be firmly and evenly seated on case face which forms rear of reverse clutch cavity.

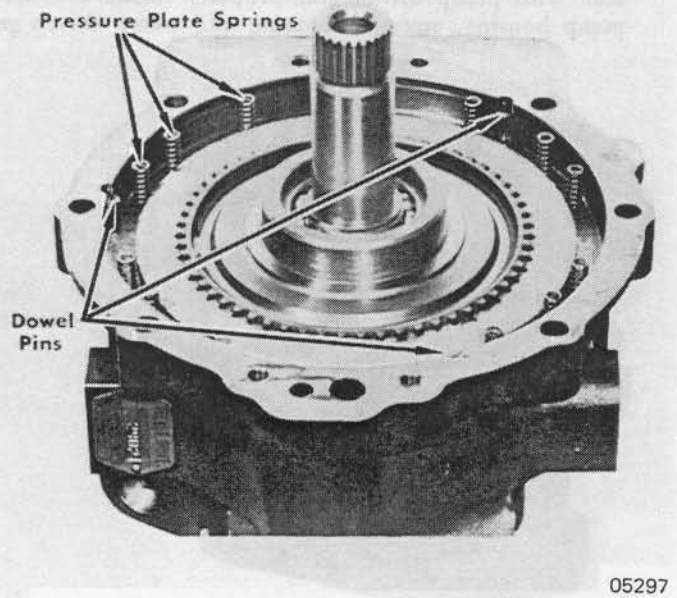

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Figure 16. Installing Pressure Plate Springs and Dowel Pins

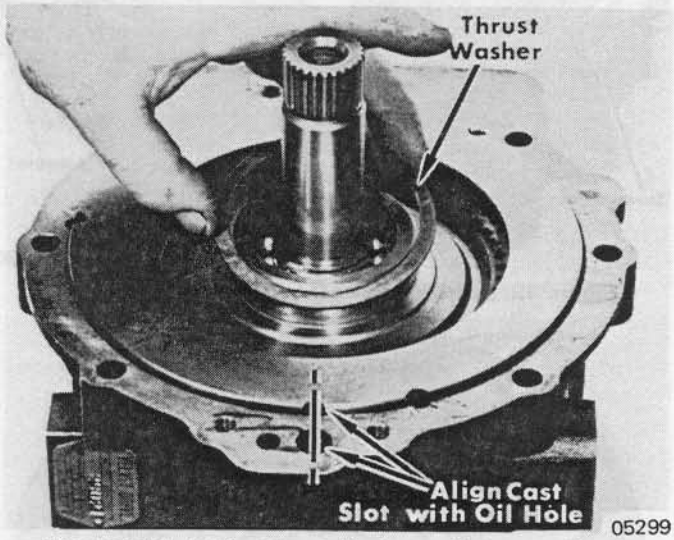

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Figure 17. Installing Thrust Washer and Reverse Clutch Pressure Plate

33. Install reverse clutch pressure plate with 12 holes in down position. Align cast slot in pressure plate with large oil hole in front face of transmission case. (Figure 12 in "Disassembly") Since 12 pressure plate springs are not evenly spaced, slot and oil hole alignment are required to locate pressure plate with relation to pressure plate springs. (Figure 12 in "Disassembly") A properly assembled reverse pressure plate will appear as shown in Figure 17. If pressure plate does not drop down to position, approximately flush with transmission case front face, check 3 dowel pins for possible misalignment.
34. Coat thrust washer with petroleum jelly and assemble. (Figure 17)
35. After checking adaptor for the following, place adaptor on clean surface in position shown in Figure 7 in "Disassembly":
    a. That needle bearing assembly is clean, properly installed and free from damage.
    b. That oil passages are free from dirt and obstruction.
    c. That the reverse clutch cavity outer wall has a smooth, clean surface, free from scratches or burrs and coated generously with petroleum jelly.

36. Coat sealing ring with petroleum jelly and install in groove of adaptor hub. (Figure 10 in "Disassembly")
37. After lubricating sealing ring with petroleum jelly, assemble in groove of reverse clutch piston as shown in Figure 9 in "Disassembly".
38. Examine inside diameter of reverse clutch piston for smooth, clean surface, free from scratches or burrs and coated generously with petroleum jelly.
39. Place reverse clutch piston on adaptor. (Figure 18) Press down on reverse clutch piston while pulling a smooth, clean screwdriver blade around exposed portion of sealing ring. This will aid chamfered bore in adaptor to compress sealing ring into groove in outside diameter of piston. Assembly can be completed by using hand pressure until

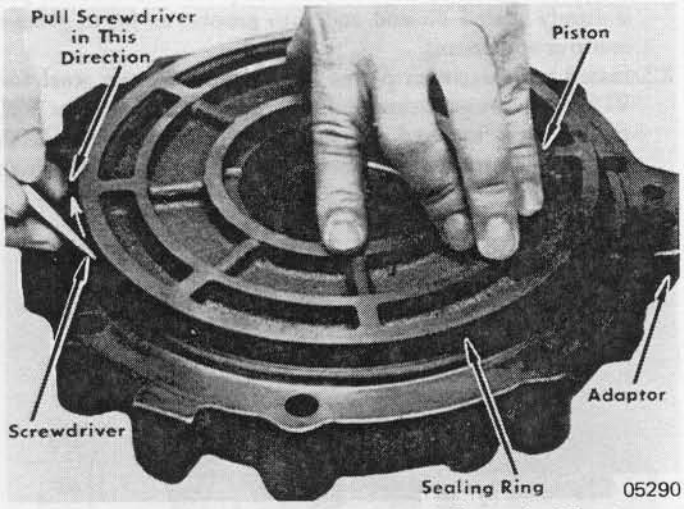

Figure 18. Installing Reverse Clutch Piston in Adaptor

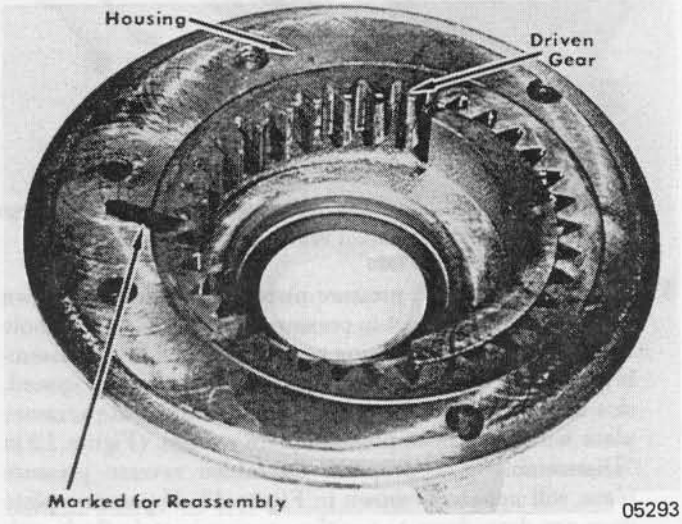

Figure 19. Installing Pump Driven Gear

piston has "bottomed" in reverse clutch cavity. Exposed face of clutch piston should be flush with adjacent surrounding surface on adaptor when assembly is completed.

40. Coat exposed front of transmission case with petroleum jelly and assemble case and adaptor gasket. (Figure 8 in "Disassembly")
41. Align oil holes as indicated in Figure 8 in "Disassembly", then lower reverse clutch piston and adaptor assembly squarely onto input gear and transmission case.
42. When shoulder on rear of adaptor has entered mating bore in reverse clutch cavity (located in front of transmission

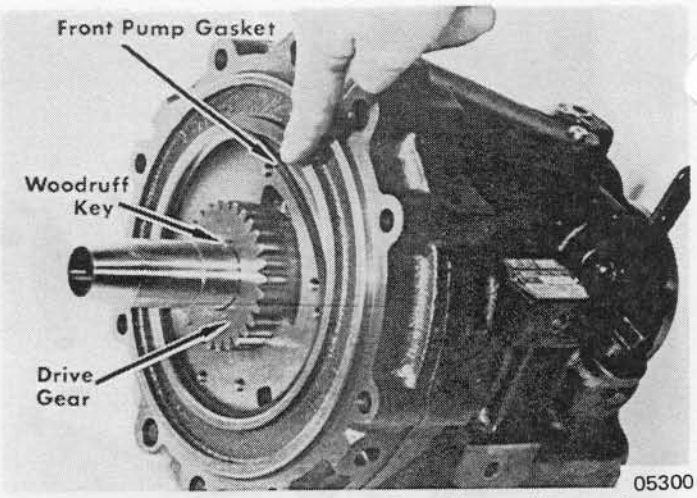

Figure 20. Installing Pump Drive Gear Key and Front Pump Gasket

case) and check of gap between case and adaptor indicates that adaptor is squarely in place, install 4 cap screws. (Figure 7 in "Disassembly") Adaptor now can be pulled down squarely, until contact with case is made, by alternately tightening cap screws a small amount and checking frequently for binding. When adaptor is pulled down as far as possible, tighten 4 screws to 27 to 37 ft. lbs. (3.73 to 5.12mkg) torque.

43. After installing new oil seal, lubricate pump housing with proper transmission oil and place as shown in Figure 19. Install lubricated driven pump gear with identification mark as shown in Figure 20.
44. Lubricate and install pump gasket. (Figure 21)
45. Install woodruff key. (Figure 19)
46. Install pump drive gear on input shaft, with woodruff key slots in drive gear mating with woodruff key on the input shaft. (Figure 19)

    NOTE: Assemble the 2 pump gears so that the same gear faces are matched with the machined face of the pump housing as found at disassembly. Marks should have been applied at disassembly to insure proper reassembly.

47. Wrap input shaft spline with tape to protect rubber lip on seal. With pump driven gear properly installed in front pump housing, assemble housing and pump driven gear

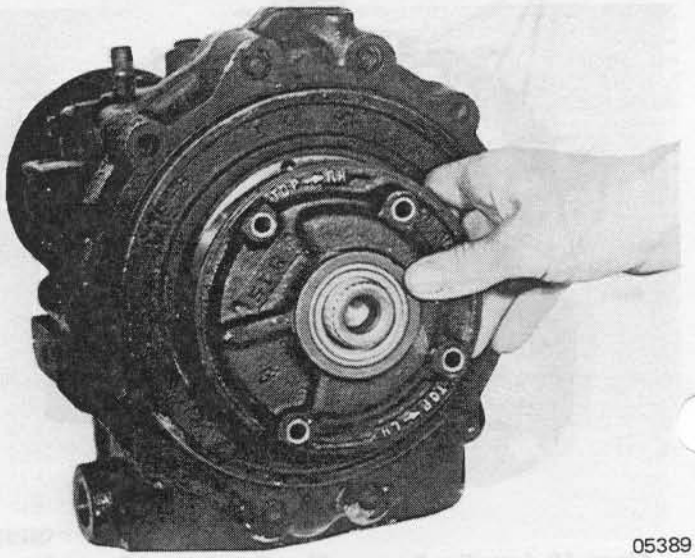

Figure 21. Installing Pump

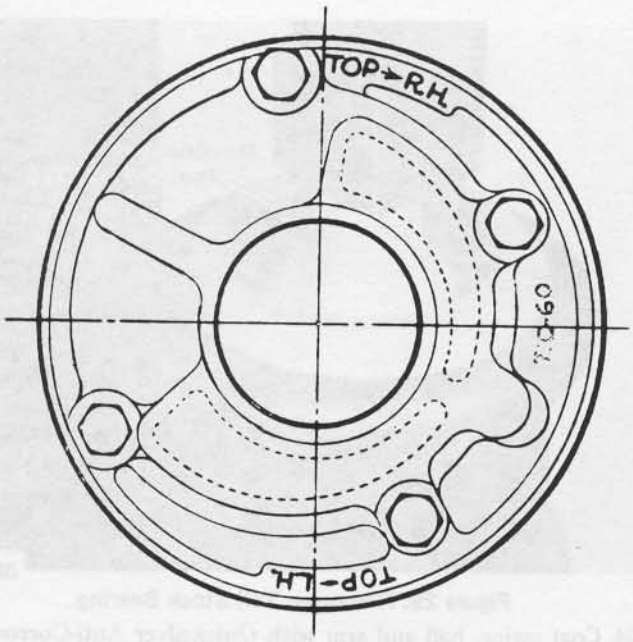

Figure 22. Orientation Marks

squarely over protruding input shaft. A slight rotation of pump driven gear will allow engagement of pump gear teeth. (Figure 21)

48. Orient pump mounting bolt holes and arrow (indicating direction of rotation) to correspond with direction of rotation required by engine, (Figure 22) If not installed for proper rotation, pump will not produce oil pressure to operate transmission when engine is started.

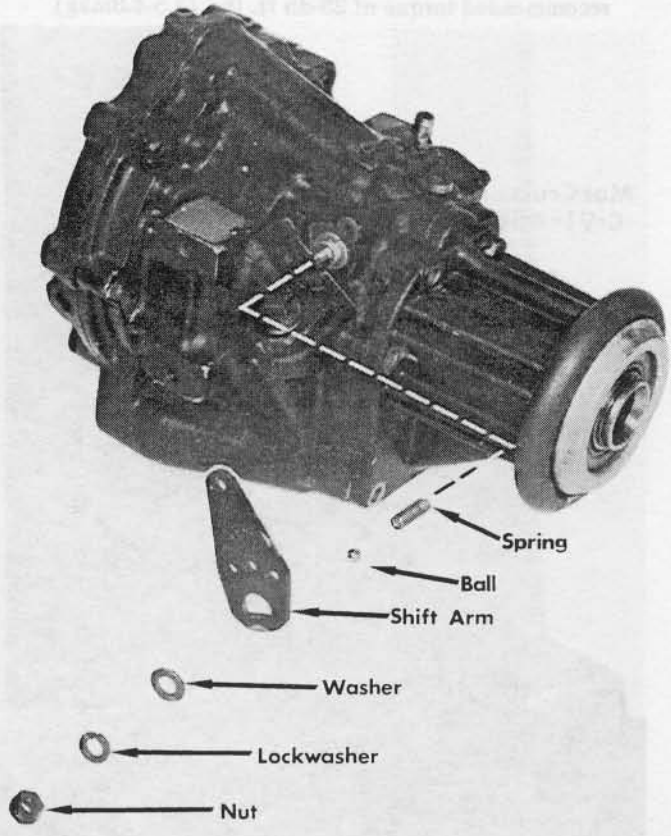

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Figure 23. Assembly of Shift Lever

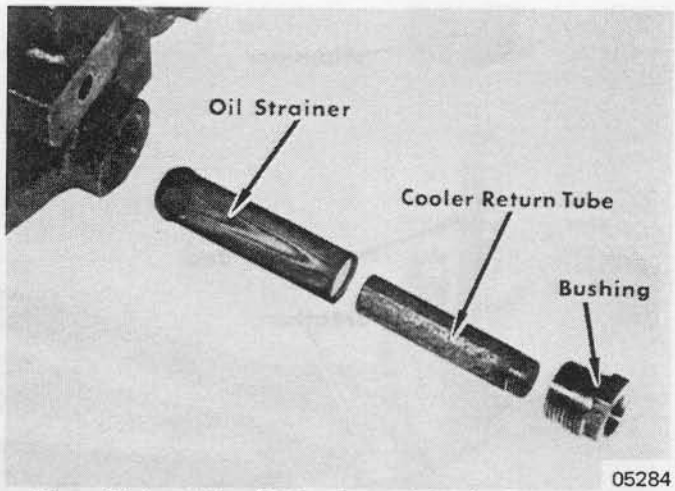

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Figure 24. Installing Oil Strainer and Cooler Return Tube

49. With pump assembled squarely against adaptor and pump gasket, install 4-5/16-18 hex head bolts. Tighten hex head bolts evenly to torque of 17-22 ft. lbs. (2.35-3.04mkg). Check freedom of rotation of pump gears in pump housing by rotating input shaft. If pump will not rotate freely, disassemble pump and check for foreign material in pump. Any dirt particles on adaptor face will cock pump when mounted on adaptor and cause it to seize.
50. Install "O" ring on end of control valve. Lubricate "O" ring with petroleum jelly.
51. Place valve and spring assembly (threaded end first in side of transmission case. (Figure 4 in "Disassembly")
52. To ensure neutral positioning of valve and easier assembly of lever, align .369"-.376" (9.37-9.55mm) width slot in valve with bottom ¼-20 bolt hole in valve cover face of case. (Figure 4 in "Disassembly")
53. Assemble valve cover gasket, valve cover, lockwashers and hex head bolts. Torque hex head bolts to 8-11 ft. lbs. (1.1-1.5mkg).

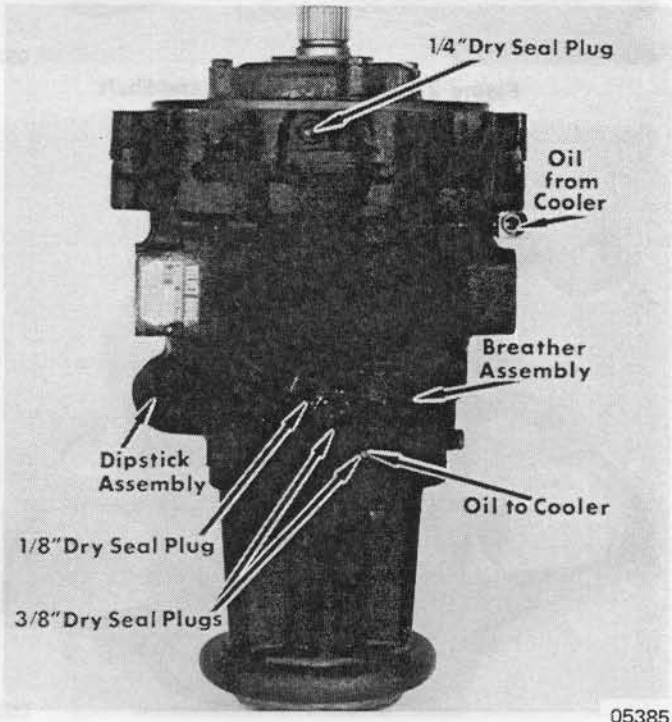

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Figure 25. Installation of Pipe Plugs

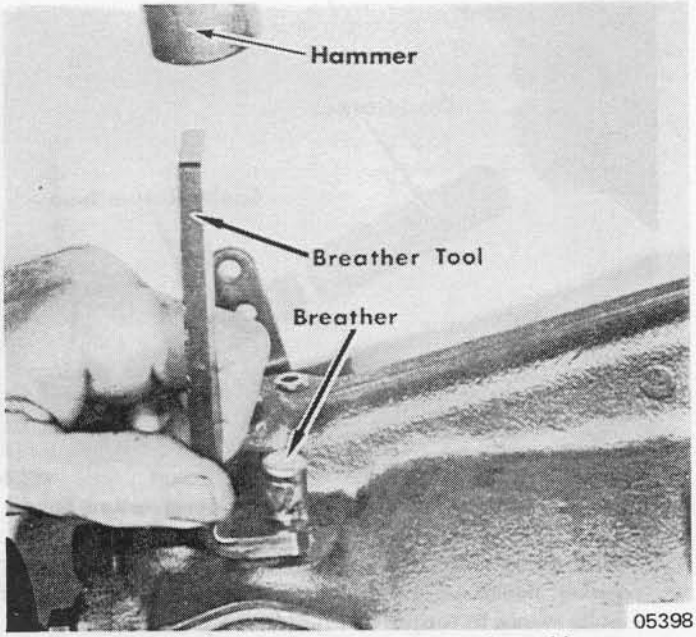


Figure 26. Installation of Breather Assembly

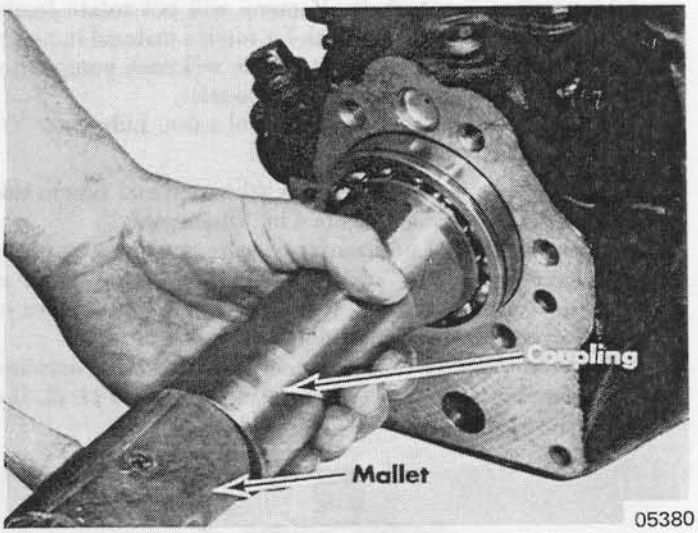


Figure 27. Installing Bearing and Shaft

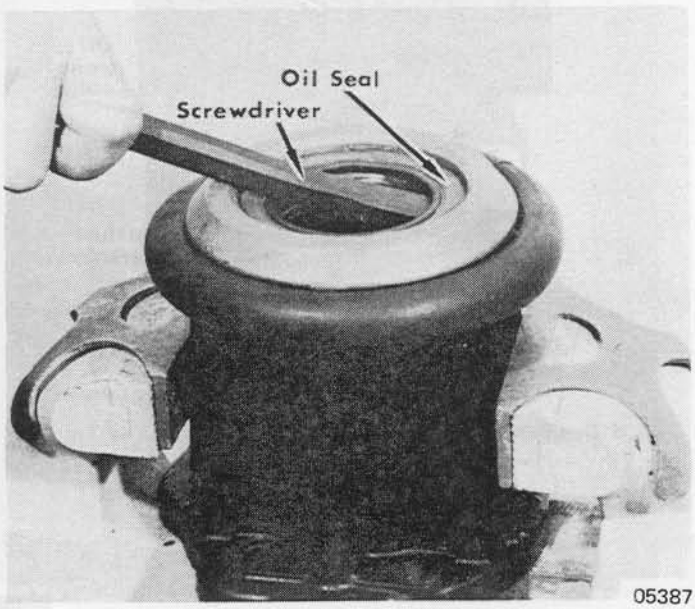


Figure 28. Removing Tail Stock Oil Seal

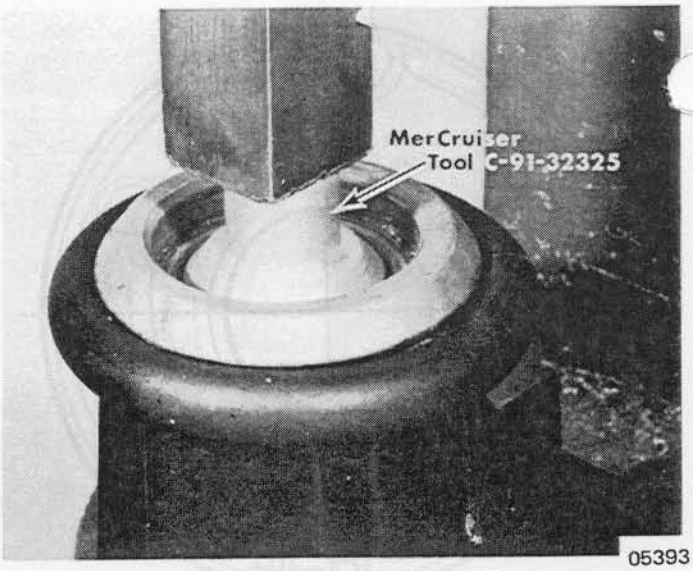


Figure 29. Removing Tail Stock Bearing

54. Coat spring, ball and arm with Quicksilver Anti-Corrosion Oil (C-92-63281). Assemble shift lever and related parts in order shown in Figure 23. Torque hex nut 8-11 ft. lbs. Rotation of valve and spring assembly thru forward, neutral and reverse positions should require no more than fingertip effort. If valve binds in rotation, remove and inspect.
55. Assemble oil strainer assembly, cooler line return bushing and cooler return tube assembly in order shown in Figure 24. Screen end of oil strainer assembly should be approximately ½" (12.7mm) below face of case when assembly is correctly installed.
    Tighten cooler line return and oil drain bushing to recommended torque of 25-35 ft. lbs. (3.5-4.8mkg).

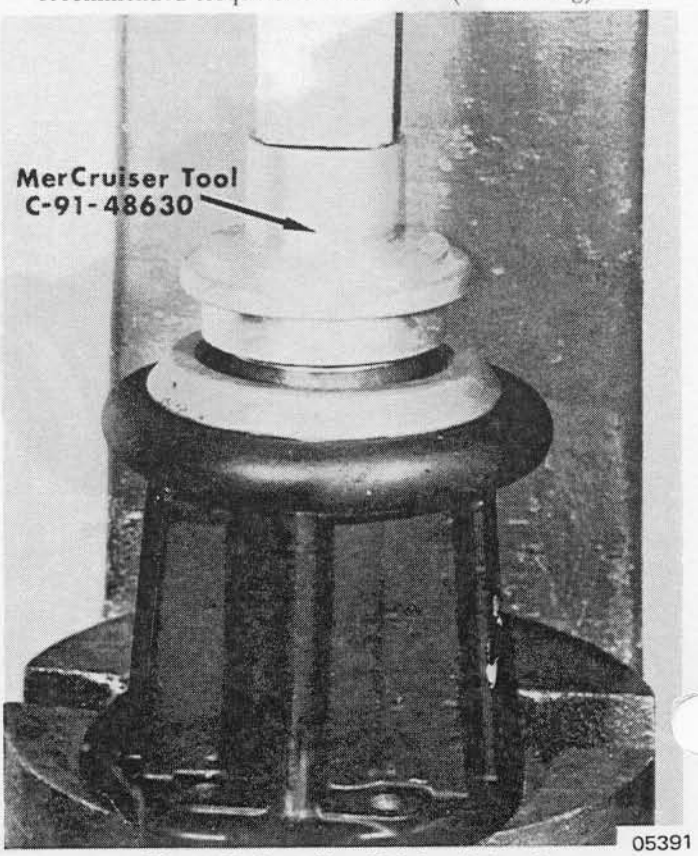


Figure 30. Installing Tail Stock Bearing

56. Install dipstick assembly and dry seal plugs (if removed). (Figure 25)
57. If breather assembly was removed, use assembly tool (Figure 26) and install new breather assembly. DO NOT hammer on top of breather assembly.

NOTE: Steps 58-thru-66 are for MerCruiser III Drive transmission only.

58. On engine coupling, check welch plug (located in center of coupling) for tightness. If loose, remove welch plug, clean surfaces, coat surfaces with Loctite and drive in new welch plug. Check oil seal. Replace if damaged.
59. Inspect coupling bearing for wear or damage. To replace, remove snap ring and press bearing off coupling. Install bearing on engine coupling. Install snap ring.
60. Install bearing coupler assembly on output shaft spline. Tap coupling with mallet to seat bearing. (Figure 27)
61. If tail stock oil seal and bearing require replacement, remove oil seal with appropriate tool. (Figure 28) Insert tool between bearing and seal and pry out seal.
62. Press bearing out of tail stock with Tool C-91-32325. (Figure 29)
63. Install new bearing with Tool C-91-48630. (Figure 30)
64. Install new oil seal with lips facing inward. Use opposite end of Tool C-91-48630, used previously.
65. Assemble gasket and tail stock housing assembly to transmission, being careful not to damge oil seal. Install 8 cap screws and lockwashers.
66. Install guide spring to engine coupling.
67. For inboard transmission with 1:1 gear ratio, replace oil seal in cover and install cover. Install engine coupling assembly and torque nut to specifications. If transmission has reduction gear assembly, install assembly and torque bolts to specifications.
68. Fill transmission with Type "A" automatic transmission fluid.

SHIFT CABLE ADJUSTMENT

MERCRUISER III DRIVE TRANSMISSION

1. Place remote control handle in full forward position.
2. Place transmission in forward gear by moving shift cable lever to the right until detent ball, which is located behind transmission shift lever, is centered in rear hole in transmission shift lever. (Figure 1)
3. Place cable end guide on stud which is located in shift cable lever. (Figure 2)

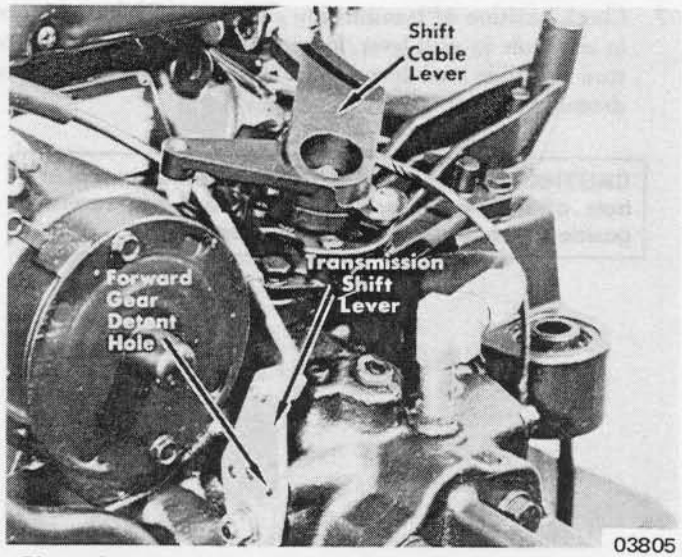


Figure 1. Transmission Shift Lever Position - Forward Gear

4. Adjust brass barrel on shift cable so that barrel can be placed on anchor stud without disturbing shift cable lever position. (Figure 2)
5. Fasten end guide to shift cable lever stud with flat washer and nut. Tighten nut and then back nut off slightly to allow end guide to pivot freely. (Figure 2)
6. Fasten brass barrel to anchor stud with flat washer and nut. Tighten nut securely. (Figure 2)
7. Place remote control handle in full reverse position.
8. Loosen nut which fastens stud to shift cable lever. Move shift cable lever to the left, while sliding stud down slot in lever, until detent ball is centered in front hole in transmission shift lever. Tighten nut securely. (Figure 3)

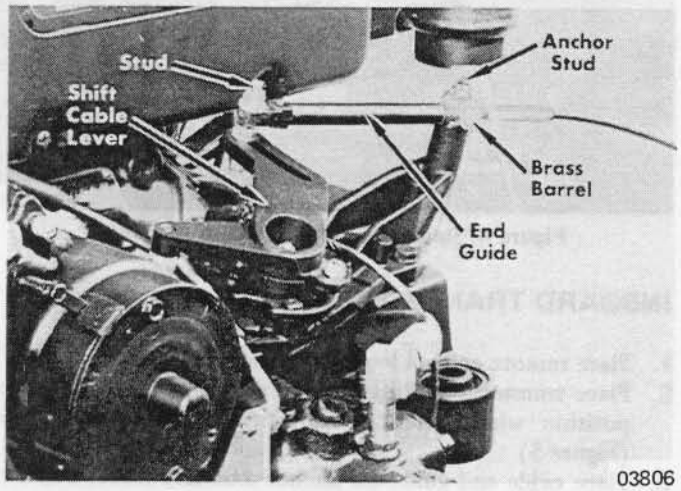


Figure 2. Shift Cable Installed

9. Check adjustment by moving remote control handle to full forward. Detent ball must be centered in rear hole in transmission shift lever. (Figure 1) Move control handle to

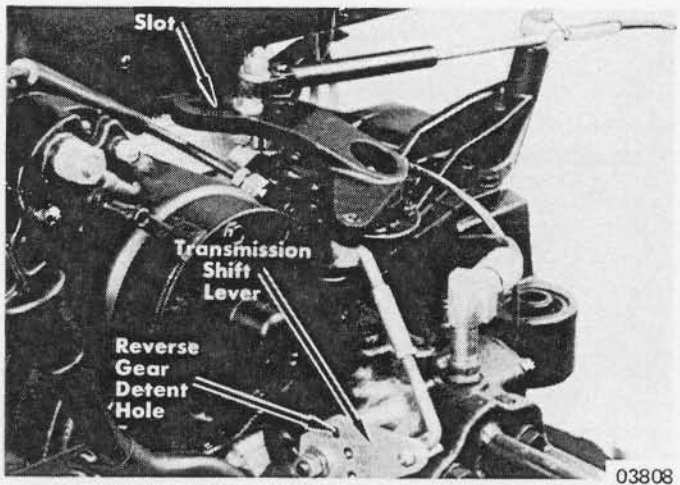


Figure 3. Transmission Shift Lever Position - Reverse Gear

full reverse position. Detent ball must be centered in front hole in transmission shift lever. (Figure 3) If transmission shift lever is not positioned correctly and does not permit detent ball to be centered in holes, as described previously, readjust cable.

REVERSE LOCK VALVE ADJUSTMENT

1. Move remote control handle to full reverse position.
2. Mark, which is located on valve cam lever, and large mark, located on valve cover, must line up as shown in Figure 4. If marks do not line up as shown, loosen nuts "A" and reposition cam lever. Tighten nuts securely after adjustment.

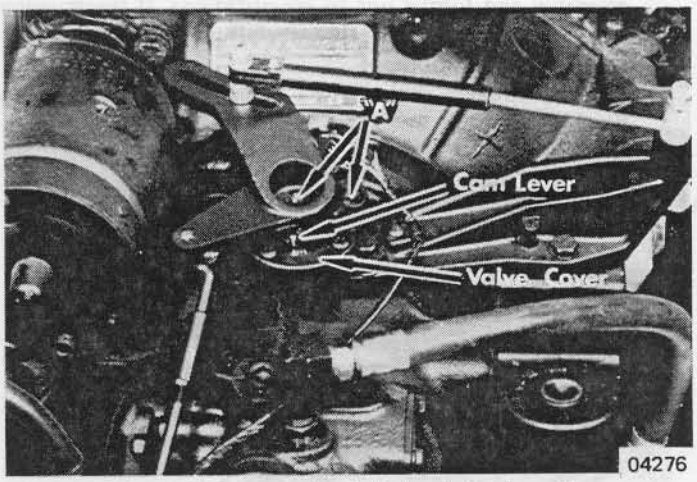


Figure 4. Reverse Lock Valve Adjustment

INBOARD TRANSMISSION

1. Place remote control lever in neutral gear position.
2. Place transmission shift lever in neutral. Lever is in neutral position when detent is in center hole of shift lever. (Figure 5)
3. Place cable end guide on anchor stud and thread barrel on cable in direction required to place hole in barrel in line with hole which is located in shift lever adaptor. (Figure 5)

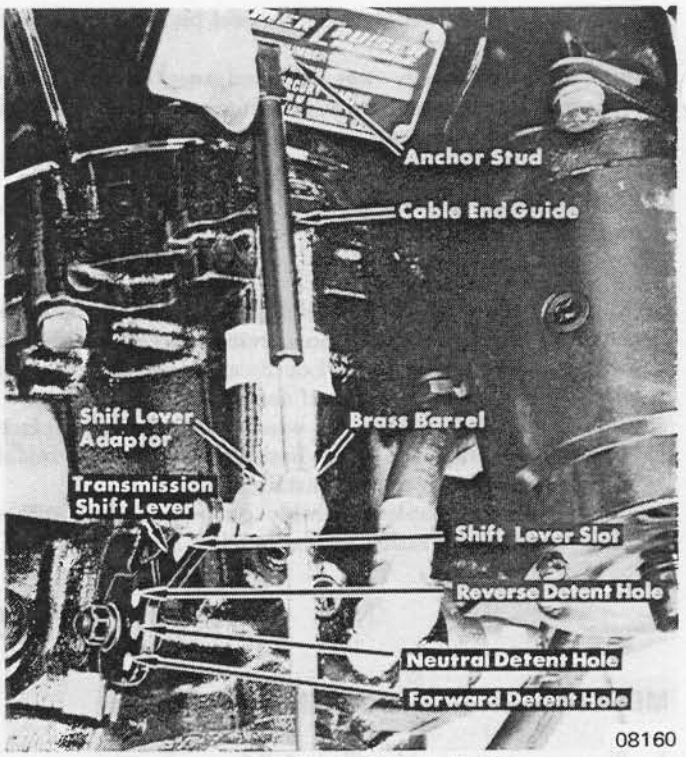


Figure 5. Shift Cable Installation

4. Fasten barrel to shift lever adaptor with screw, washer and nut. Tighten nut securely.
5. Fasten end guide to anchor stud with washer and nut. Tighten nut securely.
6. Move remote control lever to full forward gear position.
7. Check position of transmission shift lever. If detent is not in rear hole in shift lever, loosen nut on shift lever adaptor stud and slide stud down slot in lever, as required, to place detent in hole. (Figure 5)

CAUTION: Detent ball MUST BE positioned in proper hole of shift lever for neutral, forward and reverse position, or transmission will be damaged.

TOOLS

1. Special Mercury Marine tools for II-TR transmission repair are included in Kit C-91-65307A1.
2. The assembly tool drawings (shown on this page) are included to illustrate how these tools may be made. Most will provide convenience in assembling and disassembling transmission, but their functions may be performed by substitution of other objects.
3. Special "J" prefix tools can be ordered from Kent-Moore, Inc., 28635 Mound Road, Warren, Michigan 48089.

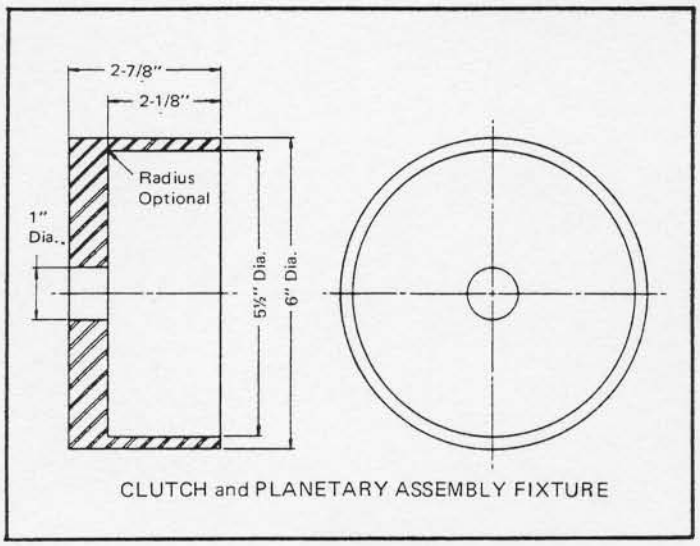


Figure 6. Drawing No. 1

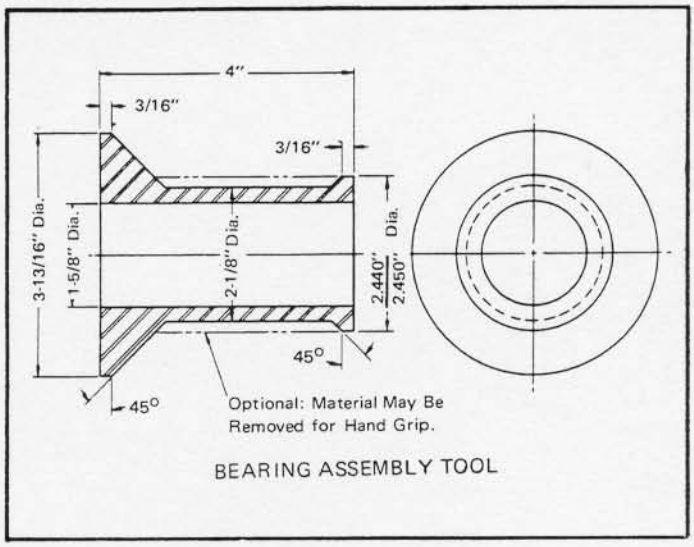


Figure 7. Drawing No. 2

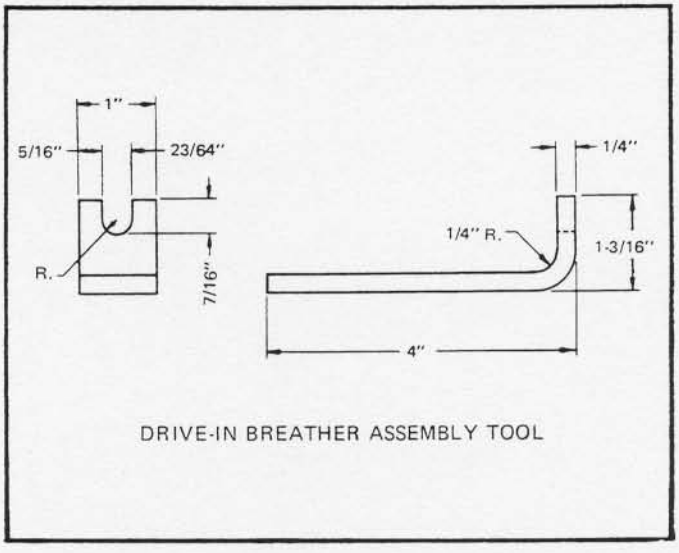
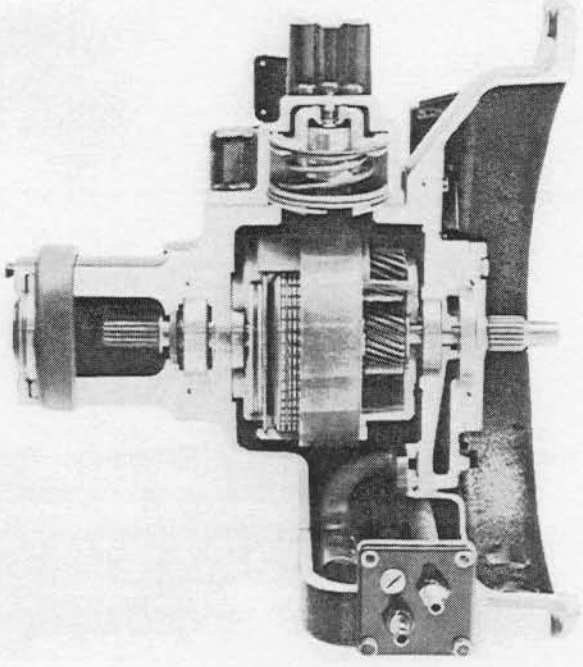


Figure 8. Drawing No. 3

SECTION 6 - DRIVE SYSTEMS

mercruiser

PART E - MERCRUISER II-TR and II-TRS TRANSMISSION



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MERCURY MARINE

A BRUNSWICK COMPANY

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MERCRUISER II-TR and II-TRS TRANSMISSION MODEL A

DESCRIPTION

The direct drive transmission consists of a planetary gear set, forward multiple disc clutch, reverse band clutch, oil pump, pressure relief valve, rotary control valve and electric shift motor. All, except the shift motor, are contained in aluminum housing and provide forward, reverse and neutral operation.

PRECAUTIONS

1. Change oil once each season.
2. Check oil level at normal engine operating temperature immediately after engine has been shut off.
3. Use clean containers for handling transmission fluid.
4. Fill transmission before starting engine.
5. Use only automatic transmission fluid (ATF) Type "A" Suffix "A" or Ford Dextron.
6. If transmission malfunctions, check transmission oil pressure and temperature. Normal pressures and temperatures are as follows:
   a. Oil temperature at normal engine operating temperature should not exceed 190°F (88°C). Oil temperature should be measured by removing plug from oil cooler (Figure 2 - "Transmission Reassembly") and installing suitable temperature gauge.
   b. Oil pressure at 750 RPM is 80-105 PSI (5.62-7.38 kg/cm^2). Oil pressure is measured by removing plug from control valve housing (Figure 4 - "Transmission Disassembly and Repair") and installing suitable pressure gauge. (Elbow C-22-54035 may be installed for ease of gauge connection. After test, plug removed from housing can be replaced in elbow.)
   c. After shifting, and pressure has stabilized, pressure must not fluctuate more than 5 PSI (.35kg/cm^2) when shifting from forward to neutral to reverse.
   d. Oil pressure in forward gear at 4000 RPM is 120-145 PSI (8.44-10.19kg/cm^2).
7. Except in emergency, never shift at engine speeds above 1500 RPM.
8. Do not permit propeller shaft to rotate for extended periods of time when transmission is inoperative. This propeller shaft rotation could be caused by towing or operation of a second engine that causes the propeller to "windmill". An inoperative stern drive should be tilted up to "trailer" position to prevent "windmilling".
9. Do not mix types or brands of automatic transmission fluid.
10. Never remove oil cooler hoses or use smaller-than-recommended 3/8" (9.5mm) inside diameter cooler hoses when operating transmission.
11. Check engine alignment each time engine is replaced.

TOOLS

Special tools, required for transmission repair, are contained in Tool Kit C-91-65307A1.

LUBRICATION RECOMMENDATIONS

Properties of oil used in the transmission are extremely important for proper function of the hydraulic system; therefore, it is necessary that recommended oil, automatic transmission fluid (ATF) Type "A" Suffix "A" or Ford Dextron, be used.

PROCEDURE for FILLING TRANSMISSION with OIL

When filling transmission, add oil until level reaches full mark on dipstick. Unit should be shifted several times at engine idle speed to ensure that all oil circuits are filled.

CAUTION: Be sure that oil cooler hoses are installed and that transmission contains oil before cranking or starting engine.

PROCEDURE for CHECKING OIL

Transmission should be checked periodically to assure proper oil level. Check oil level immediately after stopping engine. If necessary, add sufficient oil to bring transmission oil level to "Full" mark on dipstick.

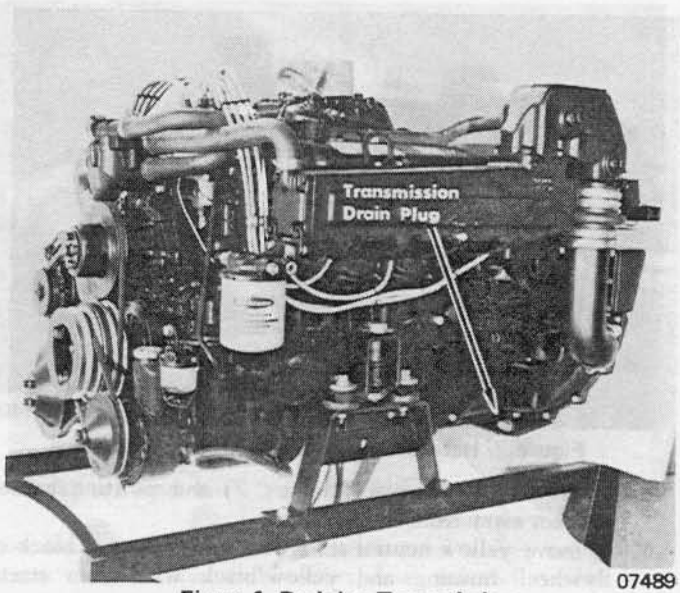

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Figure 1. Draining Transmission

CHANGING OIL

NOTE: Transmission oil must be changed once each season.

1. Place a suitable container under drain location. (Figure 1)
2. Remove drain plug. (Figure 1)
3. After transmission fluid has drained, reinstall drain plug.
4. Fill transmission to "Full" mark on dipstick (2 qts. [1.9 liters] capacity).
5. Run engine for 2 minutes at idle speed to fill all circuits.
6. Stop engine and check fluid level on dipstick. Add fluid as required to bring level up to "F" mark on dipstick.

TROUBLESHOOTING

Refer to Section 10, "Troubleshooting".

TRANSMISSION

REMOVAL

1. Shift transmission into reverse gear.
2. Remove engine and transmission from boat (refer to Section 2J).

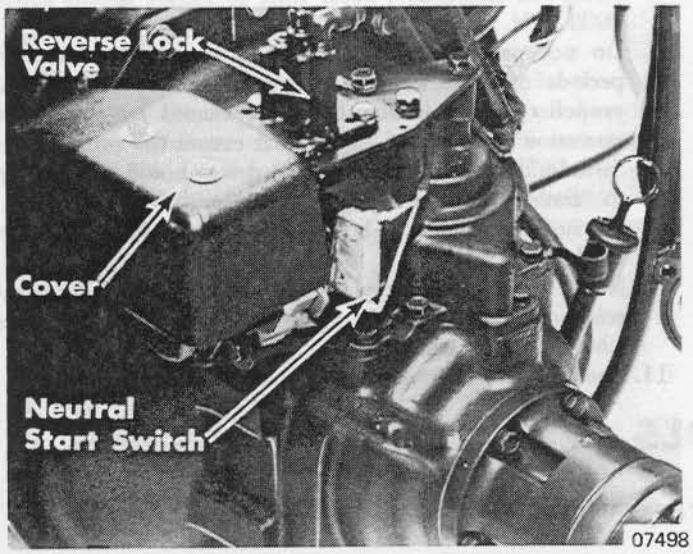


Figure 1. Shift Cover Removal

3. Remove actuator cover (Figure 1) and shifting leads. (Figure 2)
4. Remove hydraulic hoses from reverse lock valve.

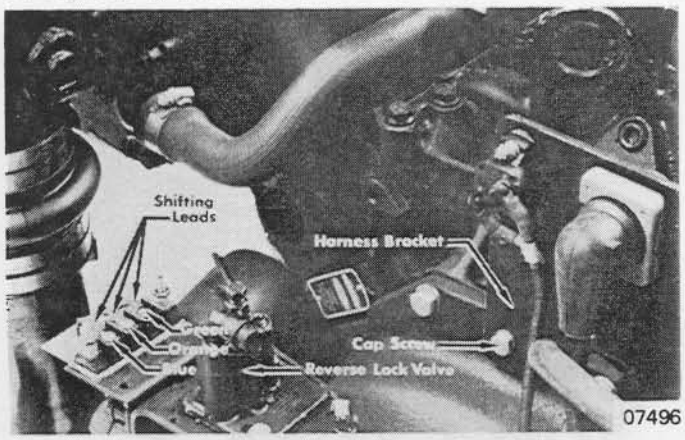


Figure 2. Harness Bracket and Shift Wire Removal

5. Remove 2 cap screws (Figure 2) and position harness bracket away from transmission.
6. Remove yellow neutral start wire from terminal block on flywheel housing and yellow/black wire from starter solenoid.

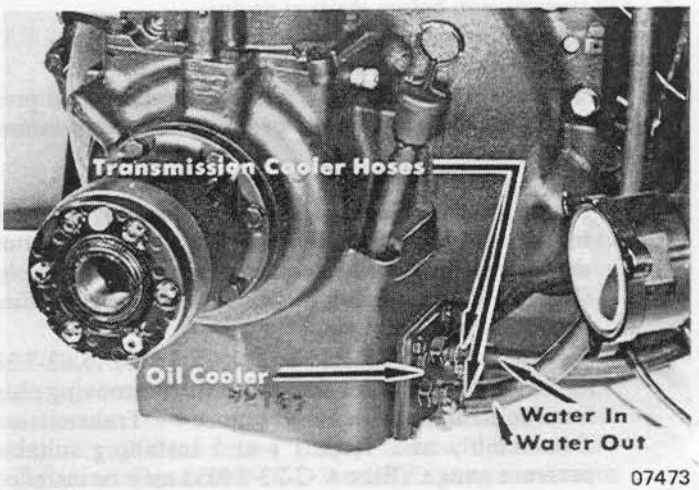


Figure 3. Transmission Hose Removal

7. Remove 2 starter motor attaching bolts.
8. Remove 2 flywheel dust cover cap screws.
9. Loosen clamps and remove cooler hoses from transmission cooler. (Figure 3)
10. Remove 6 transmission attaching cap screws and pull transmission straight back and off engine.
11. Install transmission in suitable stand.
12. Remove drain plug and drain oil from transmission. Check oil for metal particles and condensation. (Figure 4)

NOTE: All transmission parts should be thoroughly cleaned with solvent. Use compressed air to dry all parts. DO NOT use rags, as lint may cause a transmission malfunction.

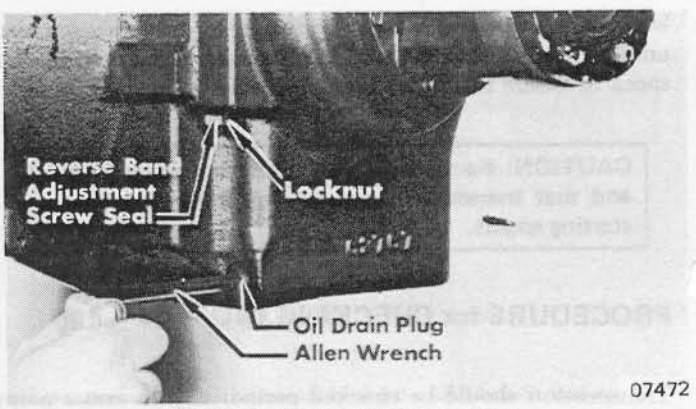


Figure 4. Draining Transmission

NOTES:

a. *Use Loctite Hydraulic Sealant on all plugs, cap screws and nuts. Using any other type Loctite may cause transmission failure.*

b. *All transmission parts should be thoroughly cleaned with solvent. Use compressed air to dry all parts. DO NOT use rags, as lint may cause a transmission malfunction.*

c. *All O-rings, seals and teflon seal rings, which are worn or damaged, must be replaced.*

1. Remove 7 cap screws from front pump cover (Figure 1), then remove cover and "O" ring. Use caution when removing cover so that oil seal is not damaged. Mark pump element location with grease pencil. Remove pump inner element (Figure 2) by inserting an allen wrench behind inner element, then pulling. Be careful not to damage inner pump element. Remove outer element.

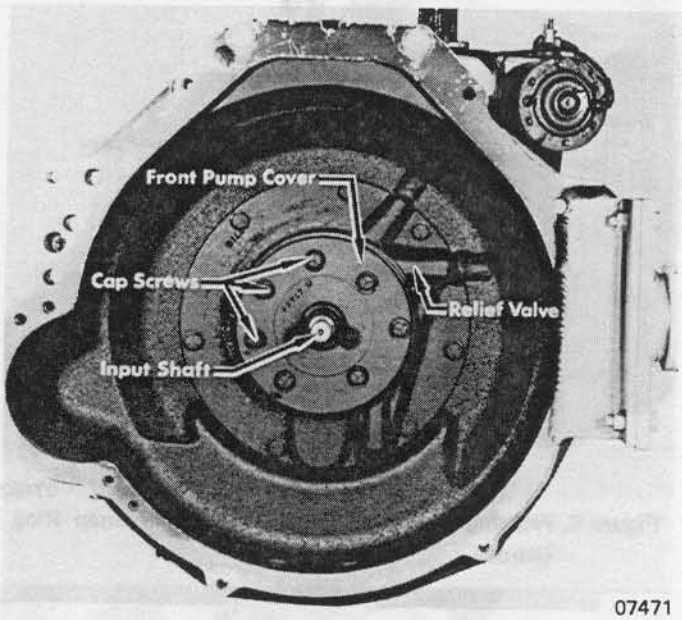


Figure 1. Removing Front Cover

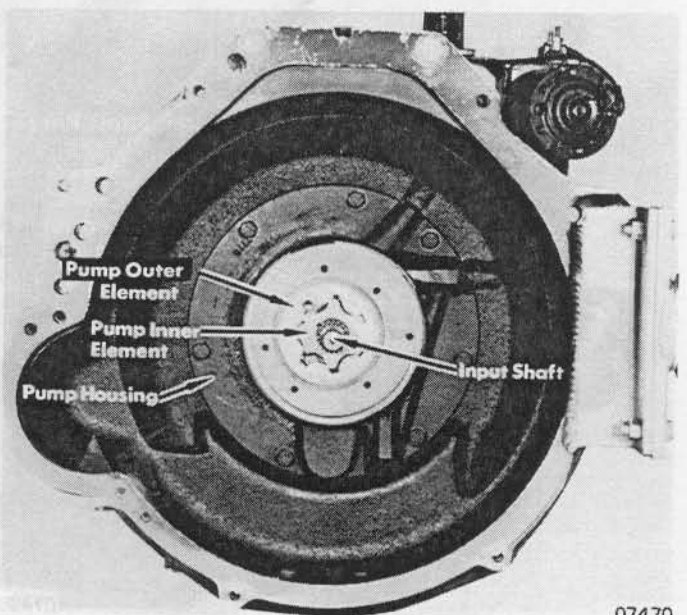


Figure 2. Removing Pump Elements

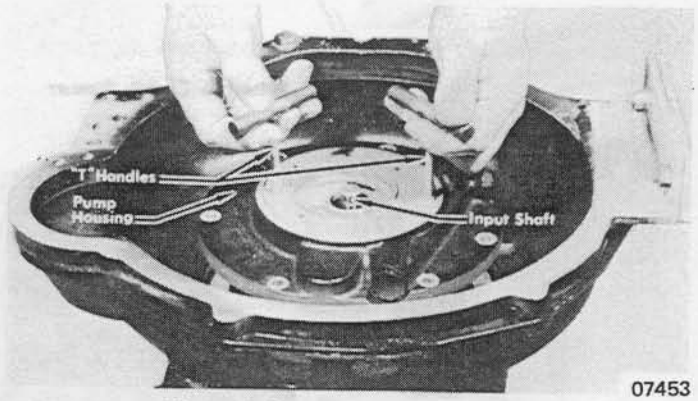


Figure 3. Pump Housing Removal

NOTE: Check input pump cover for wear. Pump cover replacement is not necessary unless cover is deeply scratched. Inspect oil seal in cover. Replace parts as necessary.

2. Remove key from input shaft before removing pump housing. Discard key. Remove 7 cap screws and install "T" handles in pump housing. (Figure 3) Pull pump housing straight out. Remove 4 "O" rings.

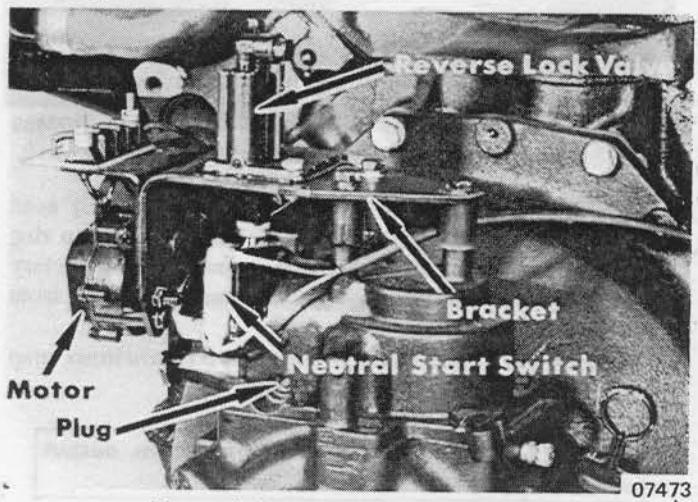


Figure 4. Reverse Lock Valve Removal

3. Remove cap screws and nuts and remove reverse lock valve if necessary for repair. Remove 4 cap screws, then remove actuating motor and bracket. Remove 2 screws from neutral start switch and remove switch. (Figure 4)

4. Remove control valve housing by removing 7 cap screws and "J" clip. Tap housing with mallet to loosen. Reach under control valve housing and hold with upward force on reverse clutch lever so that the accumulator piston will not fall out. (Figure 5) Remove gasket and "O" rings.

5. Remove reverse clutch link from reverse clutch band through control valve housing opening. (Figure 5)

6. Remove 6 cap screws, then remove output housing (Figure 6) and "O" rings. Remove plain washer and "O" ring from inside of output housing. Note that washer and "O" ring will be loose inside housing.

7. Remove snap ring from output shaft with Snap Ring Pliers (C-91-24283). (Figure 7)

CAUTION: DO NOT drag snap ring across output shaft sealing surface.

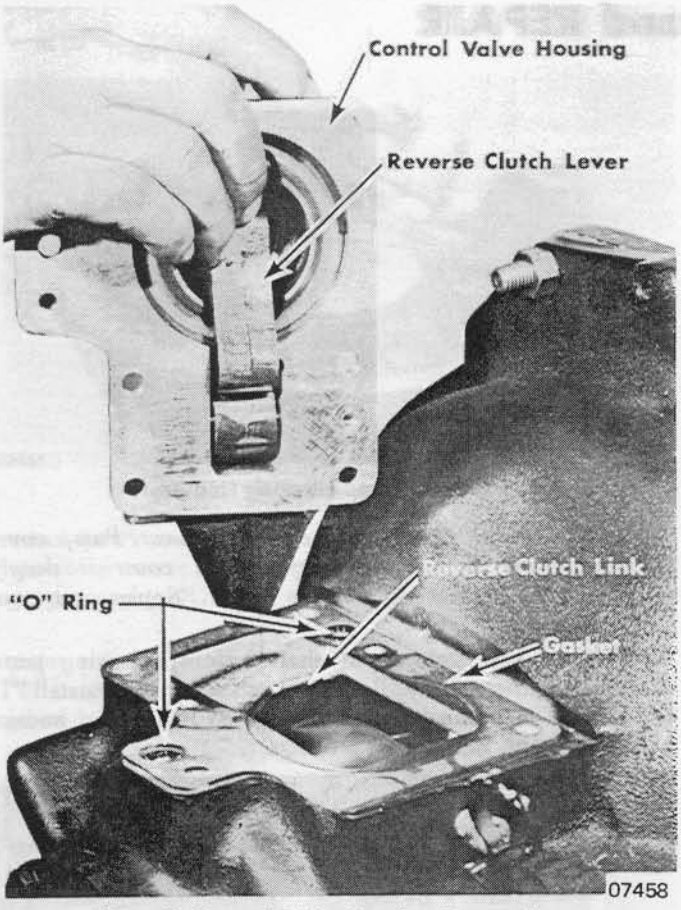


Figure 5. Control Valve Housing Removal

8. Use suitable tool to press output shaft (Figure 8) until solid resistance is felt. This indicates that inner snap ring has dropped into outer snap ring groove. Move planetary assembly toward output end to remove bearing from housing. (Figure 9)
9. Remove rear output bearing. (Figure 9) Remove inner snap ring with Snap Ring Pliers (C-91-24283).

CAUTION: DO NOT drag snap ring across output shaft sealing surface.

10. Remove planetary assembly.
11. Remove reverse band and anchor strut.
12. Remove dipstick.
13. Remove 4 cap screws from oil cooler and remove cooler. (Figure 3 in "Removal")

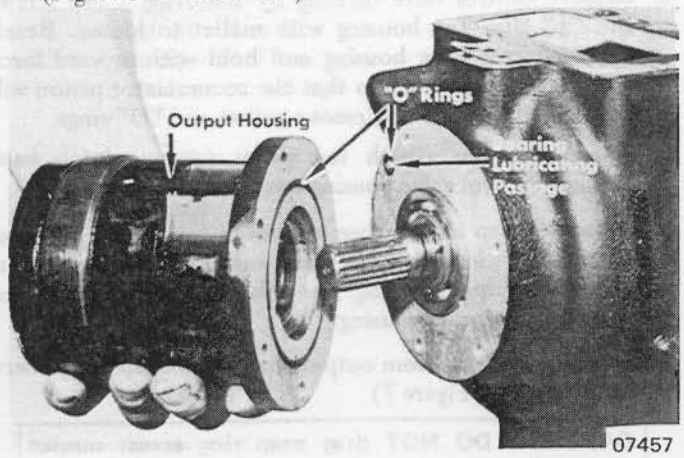


Figure 6. Output Housing Removal

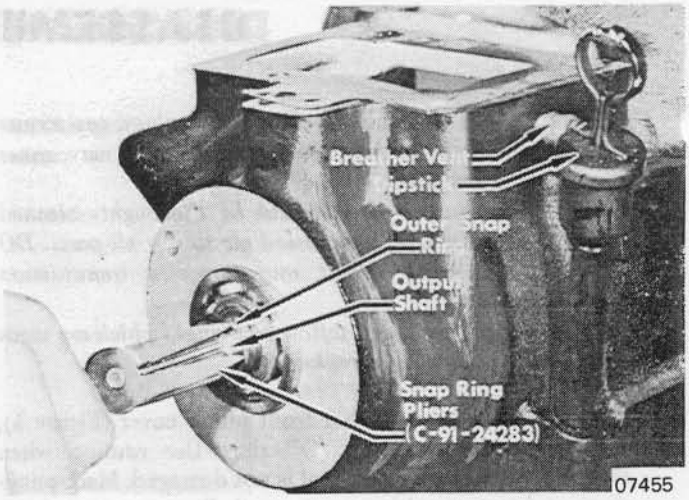


Figure 7. Outer Snap Ring Removal

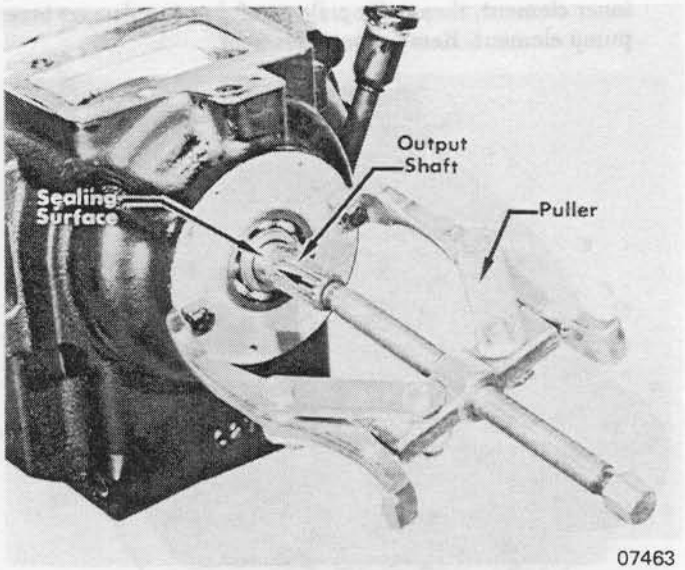


Figure 8. Pressing Inner Snap Ring into Outer Snap Ring Groove

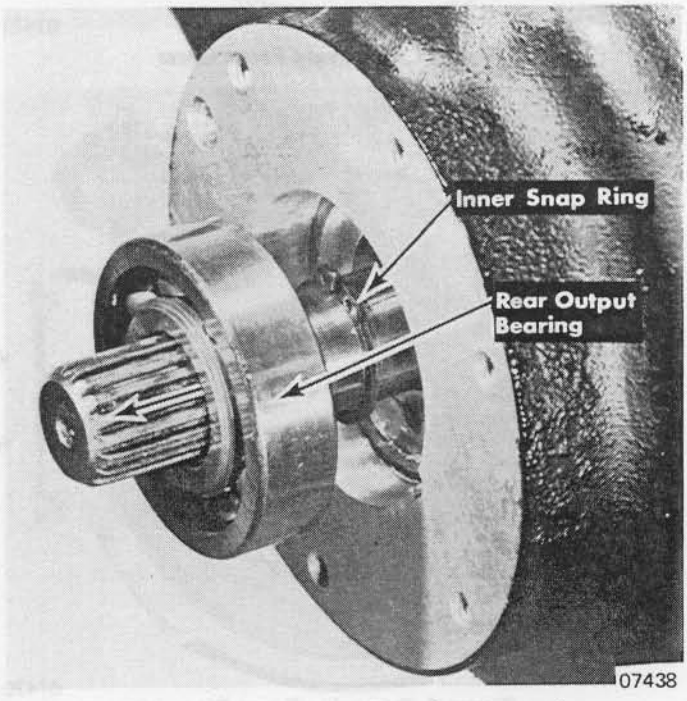


Figure 9. Snap Ring and Bearing Removal

14. Remove allen head screw, then remove oil pickup assembly and "O" ring. (Figure 10)

IMPORTANT: Lockwasher (located below allen head screw) is a special lockwasher. DO NOT use any other size lockwasher.

15. Remove breather vent and clean. (Figure 7)
16. Loosen locknut and "back out" reverse band adjustment screw several turns.
17. Inspect reverse band adjustment screw seal and replace as necessary. (Figure 4 in "Removal")

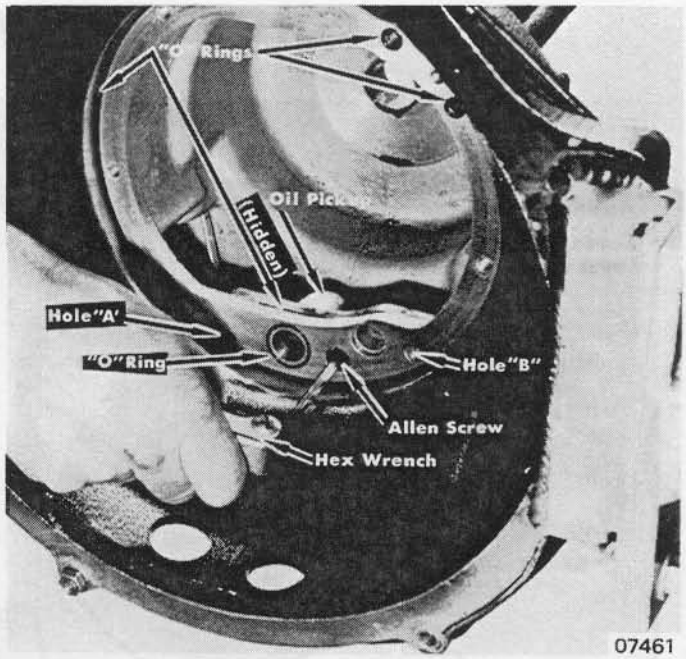


Figure 10. Oil Pickup Removal

CONTROL VALVE HOUSING REPAIR

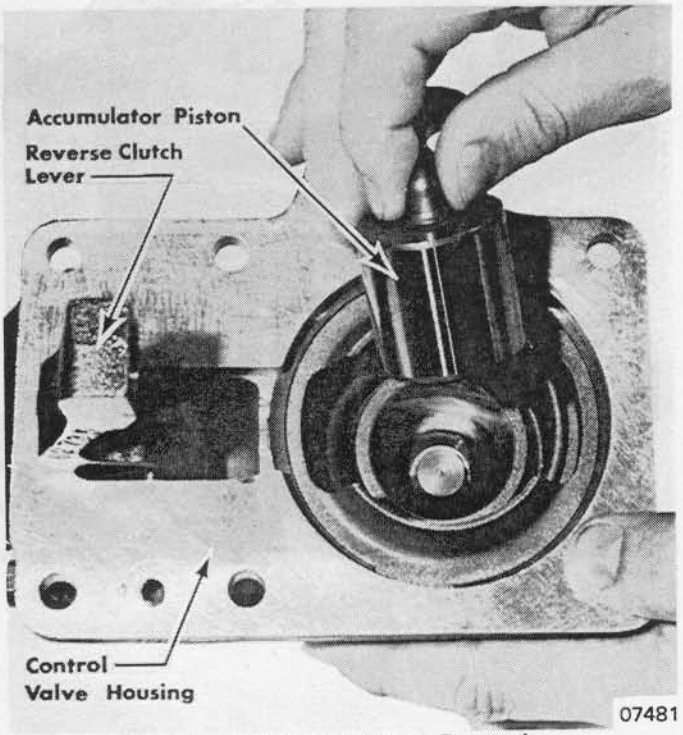


Figure 1. Accumulator Piston Removal

1. Pull out accumulator piston. (Figure 1)
2. Press retainer down on press with Piston Housing Compressor and remove snap ring. (Figure 2)
3. Remove retainer, servo spring and servo piston with check valve and spring. Check "O" ring on servo piston for wear. (Figures 3 and 4)

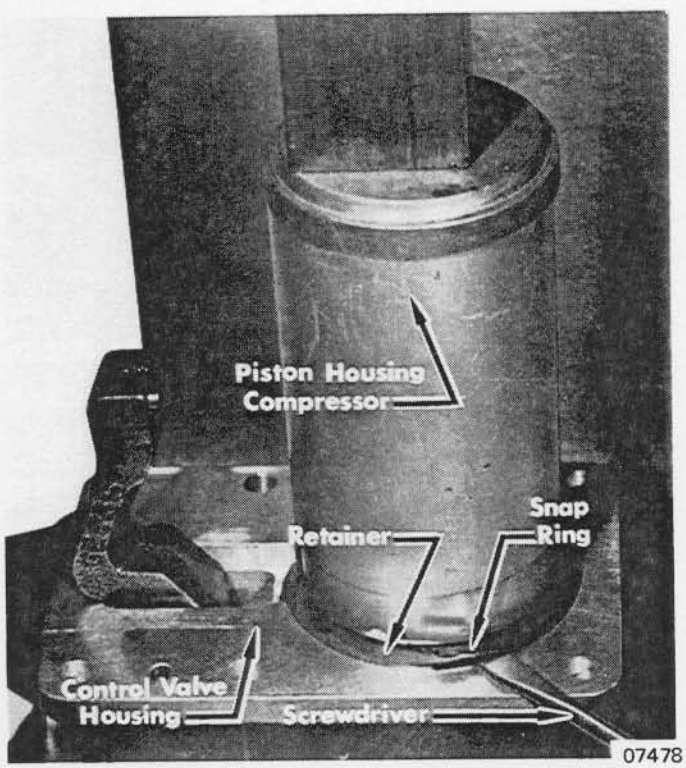


Figure 2. Snap Ring Removal

4. Reverse clutch lever may be replaced by removing welch plug, pin and bushing.

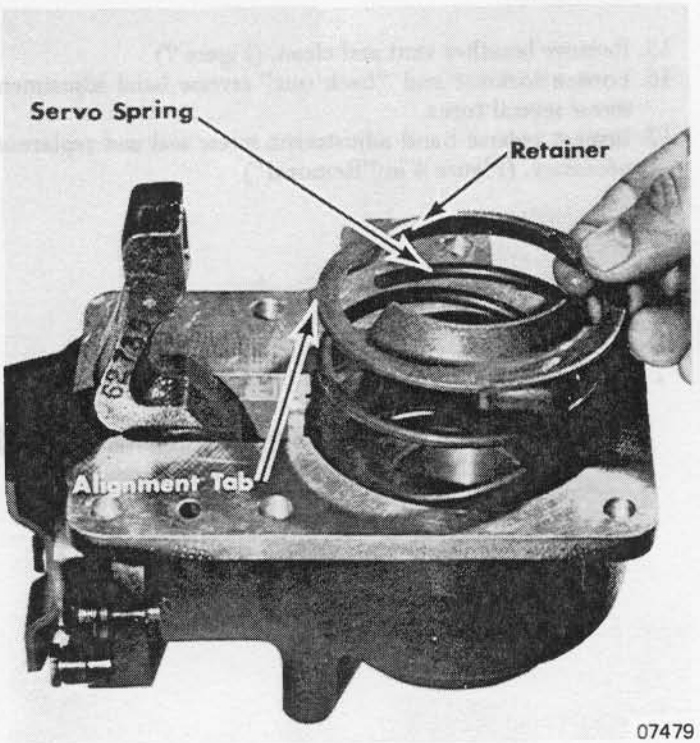


Figure 3. Servo Spring Removal

Figure 4. Servo Piston Removal

5. Remove 2 screws and remove control valve cap assembly. (Figure 5)
6. Remove control disc from control valve housing.

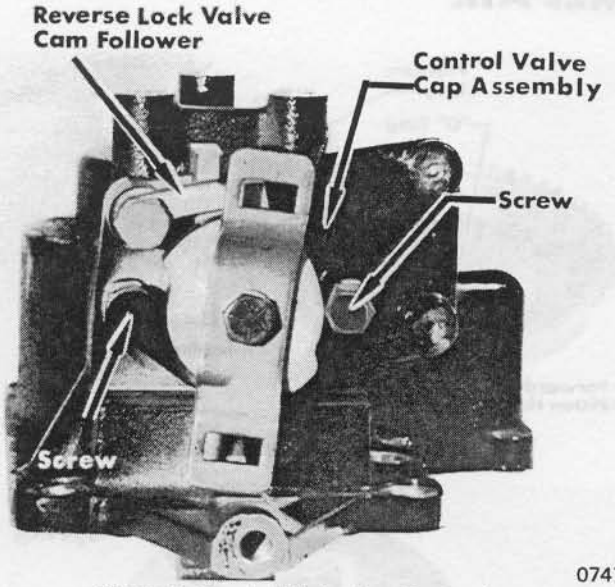


Figure 5. Control Valve Cap Removal

7. When center cap screw from control shaft is removed, assembly pulls apart. Check "O" rings. (Figure 6)
8. Inspect .050" washer on control shaft. Remove roll pin and replace washer, if bent.

NOTE: DO NOT remove washer from control shaft unless replacement is necessary.

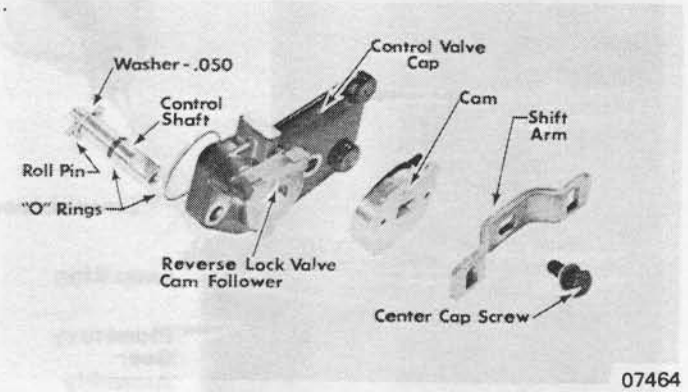


Figure 6. Control Valve Disassembly

PUMP HOUSING and RELIEF VALVE REPAIR

1. Inspect surface of pump housing which mates with pump elements. If pump housing surface between oil passages is scored or grooved, insufficient transmission oil pressure may result. Replace pump housing as necessary.
2. Remove relief valve plug, "O" ring, spring and relief valve piston. (Figure 7)
3. Inspect relief piston and passage for burrs or wear. Check plug and "O" ring for damage.
4. Remove oil discharge passage plug and check "O" ring. (Figure 7)

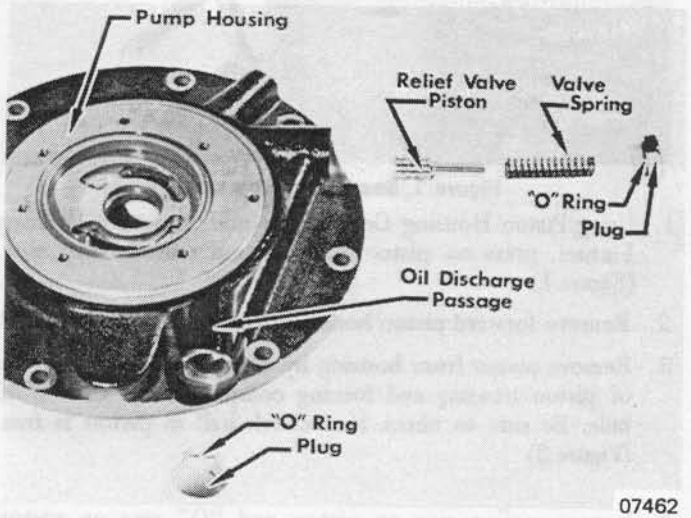
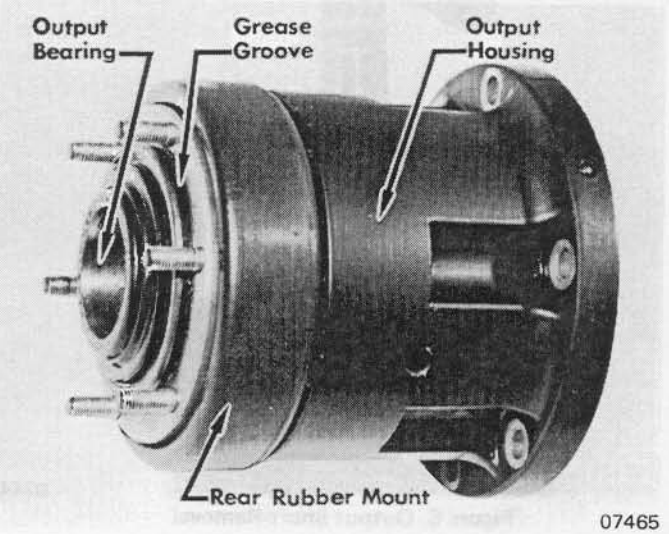


Figure 7. Relief Valve Removal

OUTPUT HOUSING REPAIR and REASSEMBLY



1. Remove 6 nuts from bearing retainer and remove retainer.
   NOTE: Retainer studs must protrude 5/8" (15.9mm) ± 1/16" (1.6mm) from output housing.
2. Inspect bearing for roughness and excessive play. DO NOT remove bearing unless replacement is necessary. Install new bearing with grease groove out. (Figure 8)
3. Inspect rear rubber mount and replace if cracked or torn.
4. Inspect oil seal and replace if damaged or leaking. Use Seal Installing Tool (C-91-68762).
5. Install bearing retainer with 6 nuts. Grease fitting should be "up".
   NOTE: DO NOT tighten 6 nuts until engine is installed in boat.
6. Lubricate rubber mount when installing in boat.

Figure 8. Output Bearing Removal

Figure 1. Snap Ring Removal

1. Using Piston Housing Compressor and Planetary Holding Fixture, press on piston housing and remove snap ring. (Figure 1)
2. Remove forward piston housing from planetary. (Figure 2)
3. Remove piston from housing by covering 2 holes in center of piston housing and forcing compressed air thru third hole. Be sure to check that check ball in piston is free. (Figure 2)
4. Inspect sealing ring on piston and "O" ring on piston housing and replace if cut or torn. (Figure 3)

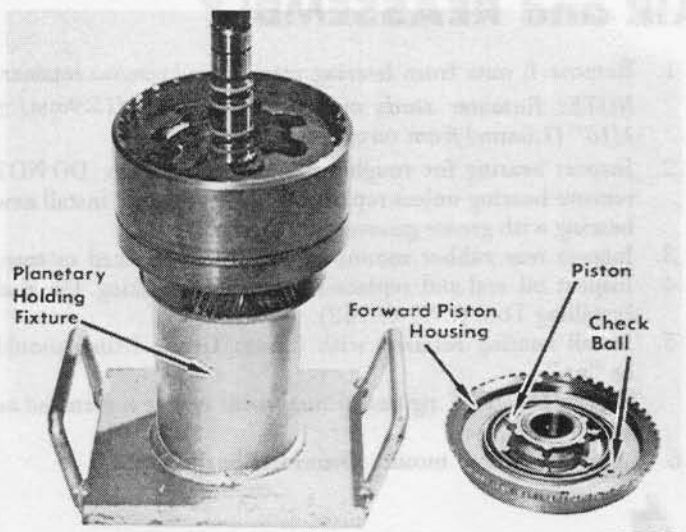


Figure 2. Forward Piston Housing Removal

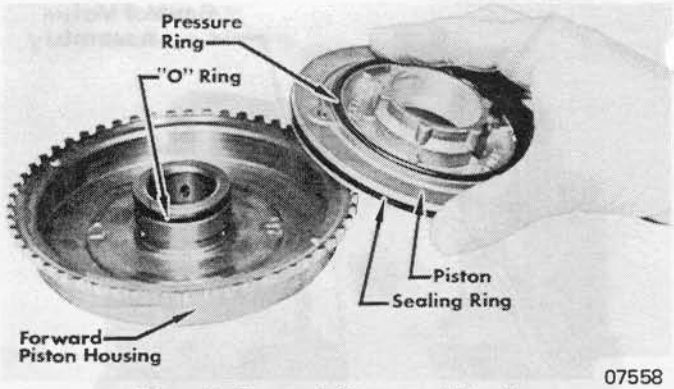


Figure 3. Forward Piston and Housing

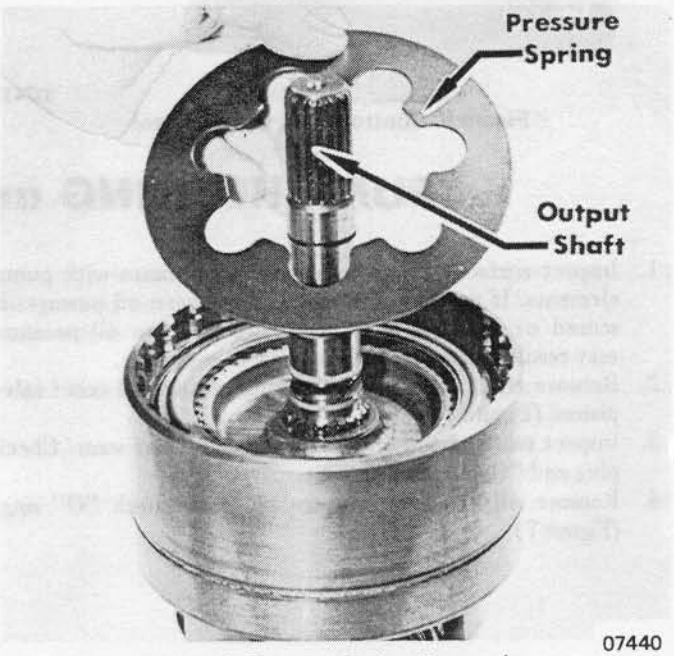


Figure 4. Pressure Spring Removal

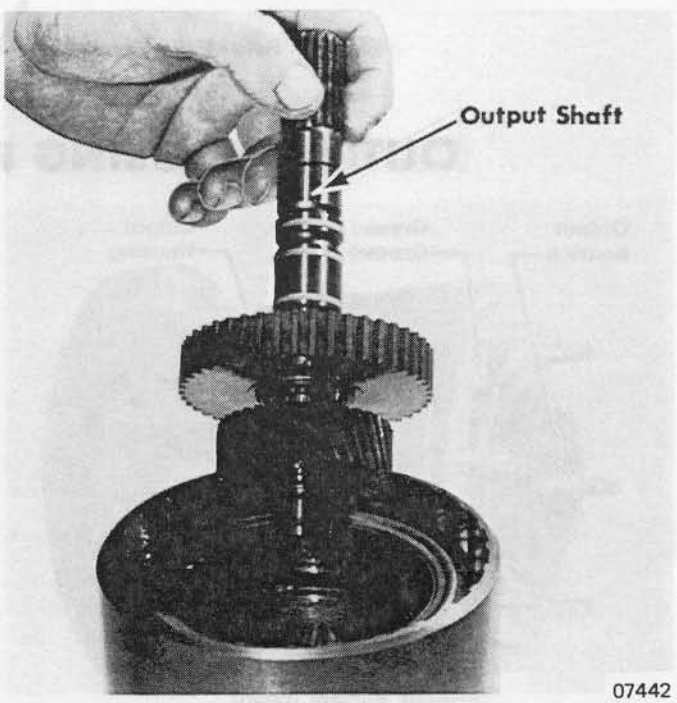


Figure 5. Output Shaft Removal

5. Check bearing in piston housing for roughness and excessive play.

NOTE: Be sure that piston housing bearing is pressed all-the-way into housing.

6. Remove pressure spring. (Figure 4)
7. Remove output shaft and thrust bearing. (Figure 5)
8. Lift pressure plate to snap ring and measure clutch pack clearance. Clearance should be .020-.050" (.51-1.27mm) between clutch plates and pressure plate. (Figure 6)

NOTE: If clutch pack clearance is not within tolerances, fiber-faced disc(s) of correct thickness must be inserted during reassembly to obtain the proper clearance.

9. Remove snap ring (Figure 7), pressure plate, clutch pack and thick spacer plate. (Figure 8) Check plates for flatness.

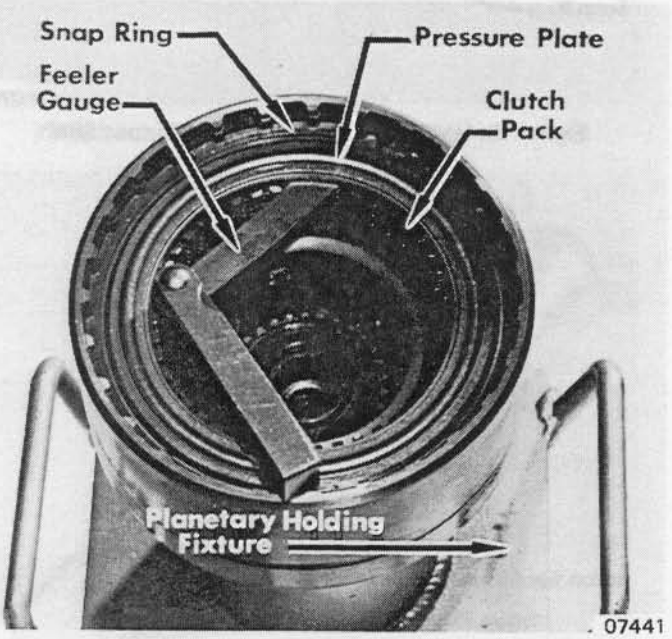


Figure 6. Determining Clutch Pack Clearance

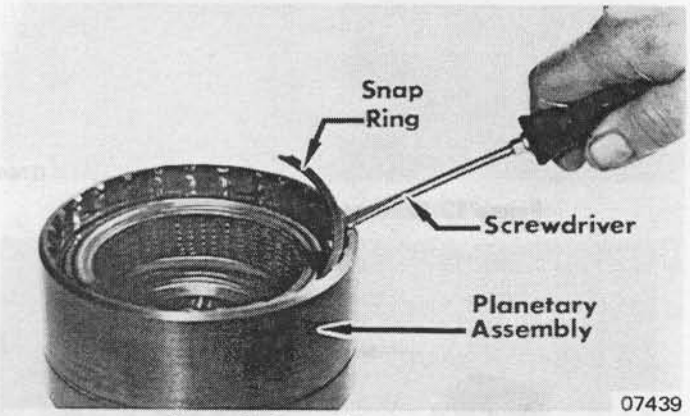


Figure 7. Snap Ring Removal

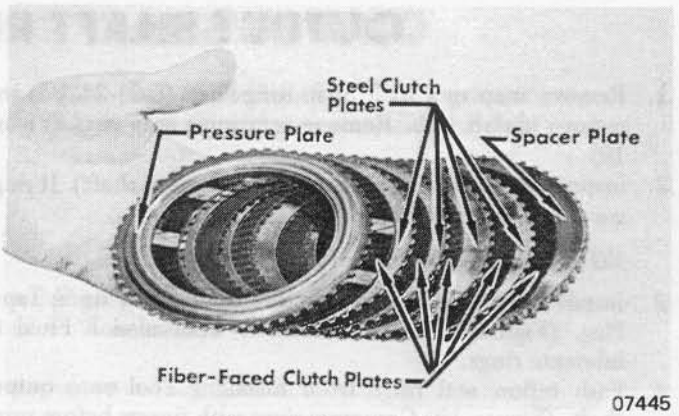


Figure 8. Clutch Pack

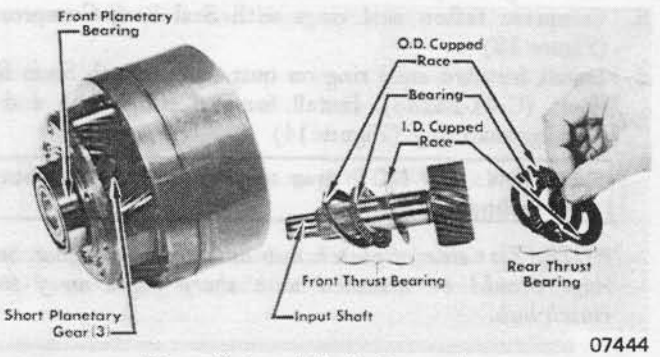


Figure 9. Input Shaft Removal

IMPORTANT: All plates must be checked for flatness. Plates must be replaced if they are warped.

10. Remove input shaft and thrust bearings. (Figure 9) (Thrust bearings may be one-piece bearings) Inspect needle bearing in input shaft and inspect input shaft.

NOTE: Input shaft will perform satisfactorily although surface of input shaft, which rides on planetary bushing, is discolored or slightly "galled".

11. Inspect front planetary bearing (Figure 9) and replace bearing if necessary.
12. Inspect input shaft support bushing in planetary. Shallow scratches or grooves in support bushing are acceptable and do not necessitate replacement of planetary assembly.
13. Check the 3 short planetary gears for end clearance. (Figure 9) Replace planetary assembly if excessive movement is found.

NOTE: Excessive movement of small planetary gears will occur if flat surface of needle bearings is visible. This condition will result if the thin washer between gear and planetary housing was badly "scored" or has completely disintegrated.

OUTPUT SHAFT REPAIR and REASSEMBLY

1. Remove snap ring with Snap Ring Pliers (C-91-24283) and remove clutch hub. Remove remaining snap ring. (Figure 10)
2. Inspect teflon seal rings (located on output shaft). If rings are cut or scratched, remove and discard.

   NOTE: Replace teflon seal rings in a set only.

3. Install teflon seal rings onto Installing Tool, using Taper Plug. (Figure 11) Use Automatic Transmission Fluid to lubricate rings.
4. Push teflon seal rings from Installing Tool onto output shaft. (Figure 12) Compress rings with fingers before using Seal Ring Compressor Tool.
5. Compress teflon seal rings with Seal Ring Compressor. (Figure 13)
6. Install forward snap ring on output shaft with Snap Ring Pliers (C-91-24283). Install forward clutch hub and remaining snap ring. (Figure 14)

CAUTION: DO NOT drag snap rings across output shaft sealing surface.

NOTE: Flat side of clutch hub must be toward gear. Snap rings should be installed with sharp edges away from clutch hub.

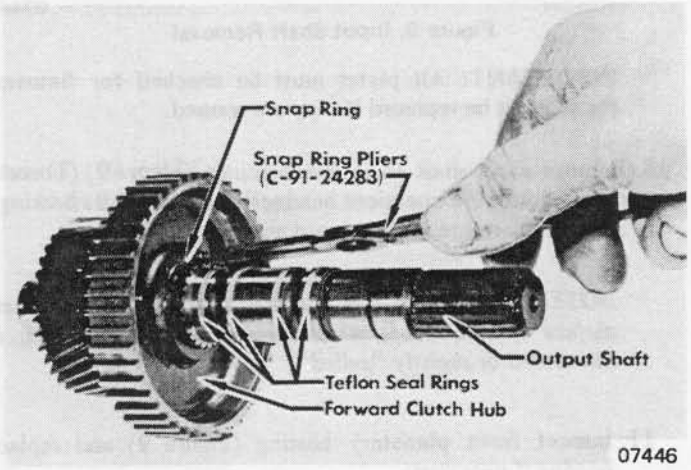


Figure 10. Removing Snap Ring from Output Shaft

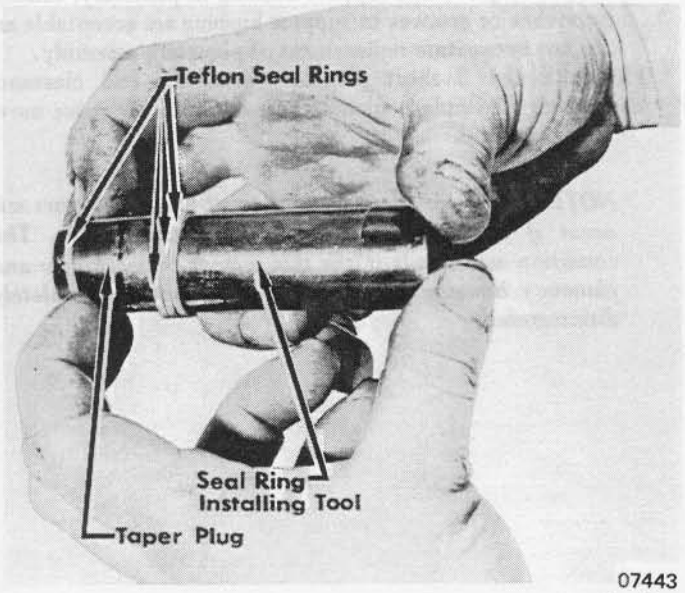


Figure 11. Teflon Seal Ring Installation on Installing Tool

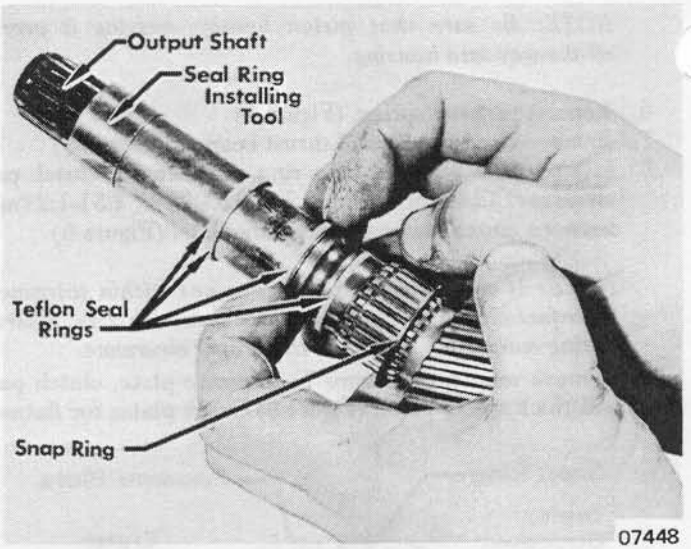


Figure 12. Installing Teflon Rings on Output Shaft

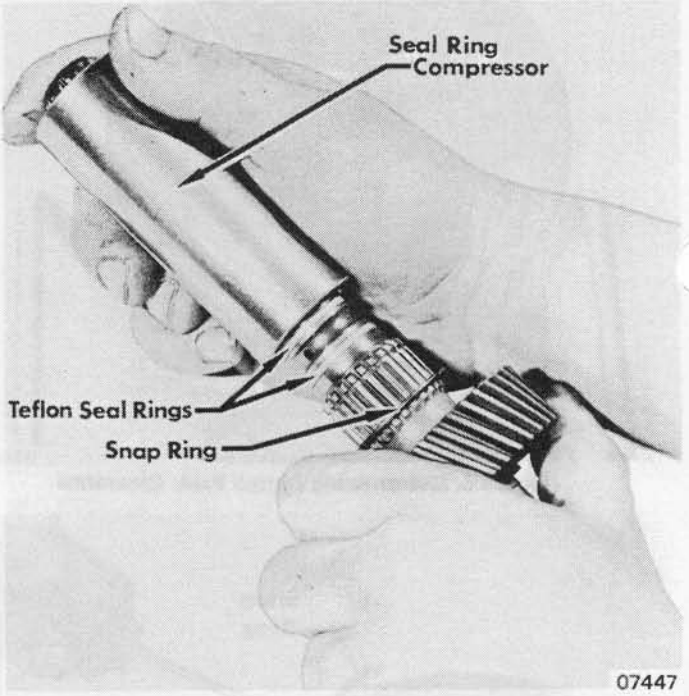


Figure 13. Compressing Teflon Rings

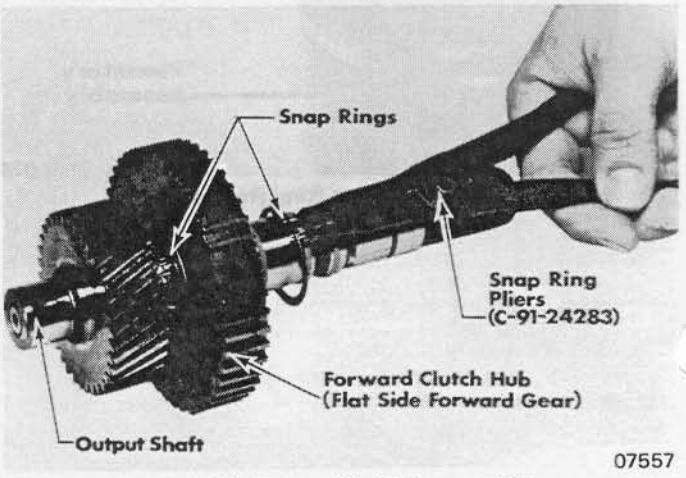


Figure 14. Output Shaft Reassembly

CONTROL VALVE HOUSING REASSEMBLY

NOTES: Refer to "Specifications" Section 8 for torque specifications.
Lubricate all "O" rings during reassembly with Multi-purpose Lubricant (C-92-63250) to prevent "O" ring damage.

1. Install "O" ring on servo piston. (Figure 4 in "Control Valve Disassembly") Install accumulator piston in servo piston. (Figure 15)

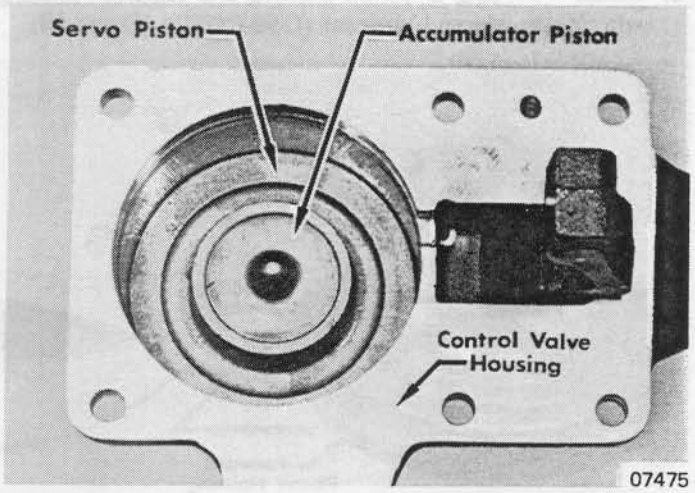


Figure 15. Servo Piston Reassembly

2. Lubricate control valve housing and servo piston with Automatic Transmission Fluid. Install servo piston in control valve housing. (Figure 15)
3. Install servo piston retaining spring, spring retainer and snap ring (Figure 3 in "Control Valve Repair"), using Piston Housing Compressor. (Figure 2 in "Control Valve Repair")
4. Lubricate control valve housing with Automatic Transmission Fluid and install control disc as shown in Figure 16.
5. Install "O" ring on control shaft. (Figure 6 in "Control Valve Repair")
6. Install control shaft in control valve cap. Install "O" ring on control valve cap. (Figure 6 in "Control Valve Repair")
7. Attach cam and shift arm to control shaft with cap screw and washer. (Figure 6 in "Control Valve Repair")

NOTE: The word "OUT" stamped on cam must be "out". (Figure 17)

8. Install control valve cap with 2 screws.

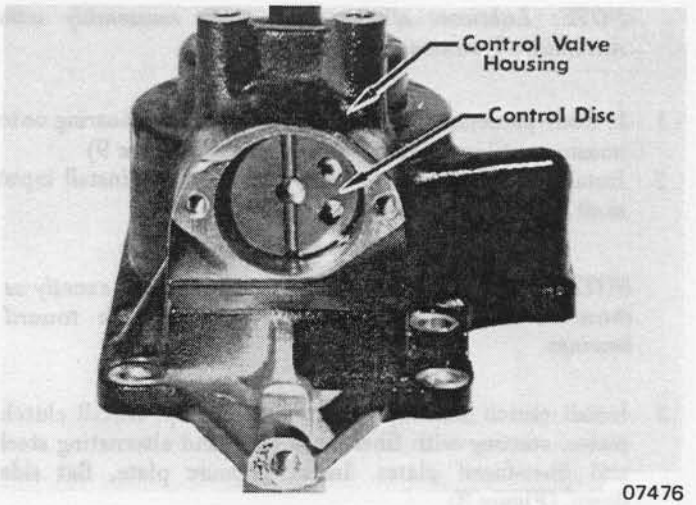


Figure 16. Control Disc Reassembly

NOTE: When roll pin in control shaft is aligned with slot in control disc, the cam must be positioned with the word "OUT" in the "up" position. Make sure that reverse lock valve cam follower turns freely.

9. Install neutral start switch on control valve assembly.

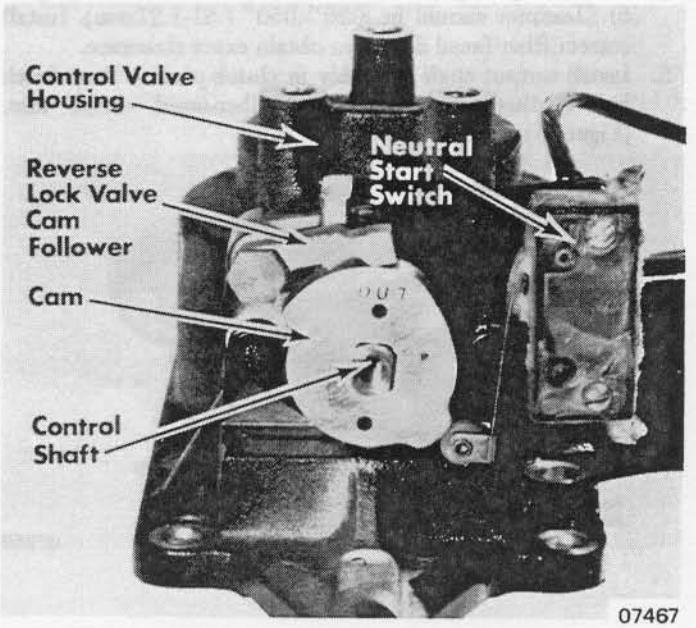


Figure 17. Cam Reassembly

PUMP HOUSING RELIEF VALVE REASSEMBLY

1. Install "O" ring and large plug in oil discharge passage. (Figure 7 in "Pump Housing Repair")
2. Install relief valve piston, spring, "O" ring and plug. (Figure 7 in "Pump Housing Repair")

PLANETARY REASSEMBLY

NOTE: Lubricate all bearings during reassembly with Automatic Transmission Fluid.

1. If front planetary bearing was removed, press bearing onto housing until inner race is firmly seated. (Figure 9)
2. Install front thrust bearing in planetary and install input shaft. Install rear thrust bearing. (Figure 9)

NOTE: Install thrust bearings with cupped races exactly as shown in Figure 9. Cupped surfaces must be toward bearings.

3. Install clutch back-up spacer, flat side up. Install clutch plates, starting with fiber-faced plate and alternating steel and fiber-faced plates. Install pressure plate, flat side down. (Figure 8)

NOTE: Lubricate clutch plates with Automatic Transmission Fluid during assembly. If new fiber-faced plates are used, soak in Automatic Transmission Fluid ½-hour before installation.

4. Install snap ring and check clutch pack clearance. (Figure 6) Clearance should be .020"-.050" (.51-1.27mm). Install correct fiber-faced disc(s) to obtain exact clearance.
5. Install output shaft assembly in clutch pack so that clutch hub is flush with outer-most fiber-faced clutch disc. (Figure 5)

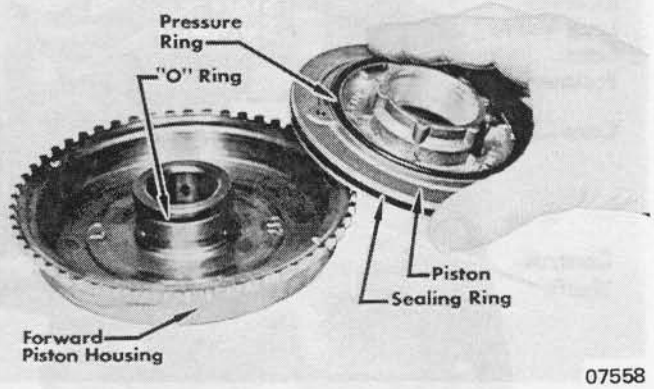


Figure 18. Forward Clutch Reassembly

6. Install pressure spring, concave (hollowed) side down. (Figure 2)

IMPORTANT: If pressure spring is installed improperly, transmission will not operate.

7. Install sealing ring and pressure ring on forward clutch piston. (Figure 18)
8. Install "O" ring in piston housing and lubricate housing with Multipurpose Lubricant (C-92-63250). (Figure 18)

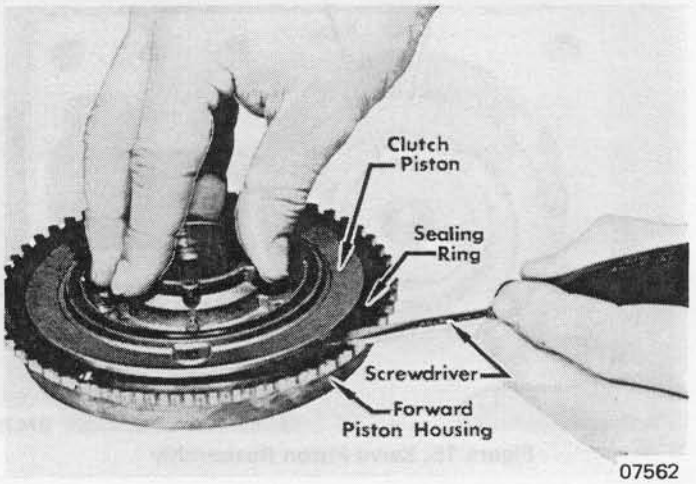


Figure 19. Installing Clutch Piston

Install piston in piston housing. (Figure 19)

NOTE: Work piston sealing ring in with screwdriver while pressing piston into housing. (Figure 19)

10. Lubricate output shaft with Automatic Transmission Fluid and install clutch piston assembly in planetary drum.

NOTE: Make sure that pressure ring (Figure 18) does not drop off piston assembly. Pressure ring must seat against pressure spring. (Figure 2)

11. Using Piston Housing Compressor and Holding Fixture, press piston housing down, then install snap ring. (Figure 1 in "Planetary Repair")
12. Check for free rotation of input and output shafts.

OIL COOLER

1. Inspect oil cooler for cracks or holes.
2. Check oil cooler for leaks. Pressurize oil cooler to approximately 40 P.S.I. (2.8kg/cm^2) with compressed air.
3. Remove gasket from oil cooler and clean gasket surface.

NOTES: Use Loctite Hydraulic Sealant on all plugs, cap screws and nuts. Using any other type Loctite may cause transmission failure.

Refer to "Specifications" Section 8 for torque specifications.

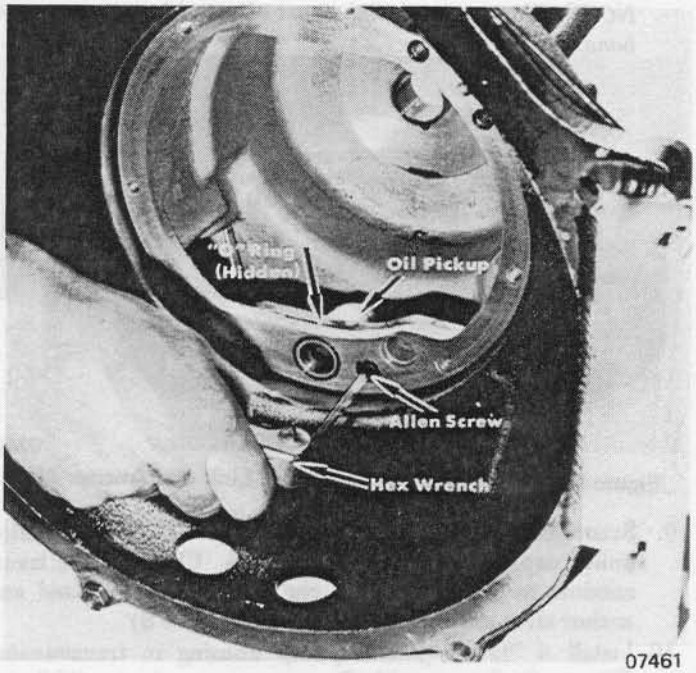


Figure 1. Oil Pickup Installation

1. Install "O" ring in groove on oil pickup tube assembly with Multipurpose Lubricant (C-92-63250). Position oil pickup in housing. Insert two 5/16-18x5/8 cap screws into holes "A" and "B" to align assembly. (Figure 1) Secure oil pickup with special lockwasher and allen head screw. Remove cap screws.

   NOTE: Lockwasher on allen screw is .047" (1.2mm) thick. DO NOT replace with another size lockwasher. Be sure that "O" ring does not fall from oil pickup during reassembly.

Figure 2. Oil Cooler Installation

2. Using a new gasket, install oil cooler with 4 cap screws as shown in Figure 2.
3. Install breather vent.

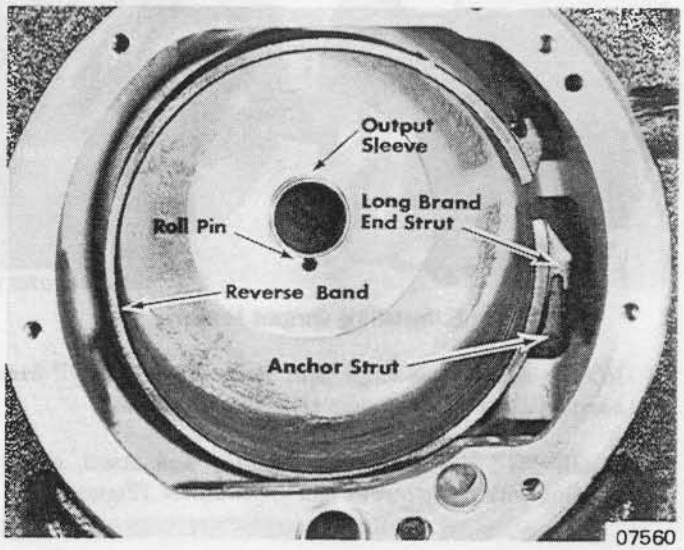


Figure 3. Reverse Band Installation

4. Install reverse band adjustment anchor screw so that anchor strut is clear of housing. Install reverse band with long band - end strut supported on anchor strut. (Figure 3)

   NOTE: Anchor strut notch must match tang in reverse band. Lubricate reverse band and output sleeve with Automatic Transmission Fluid.

CAUTION: Oil passage in output sleeve and hole in housing must line up. Roll pin must NOT be replaced with a solid pin. DO NOT remove output sleeve.

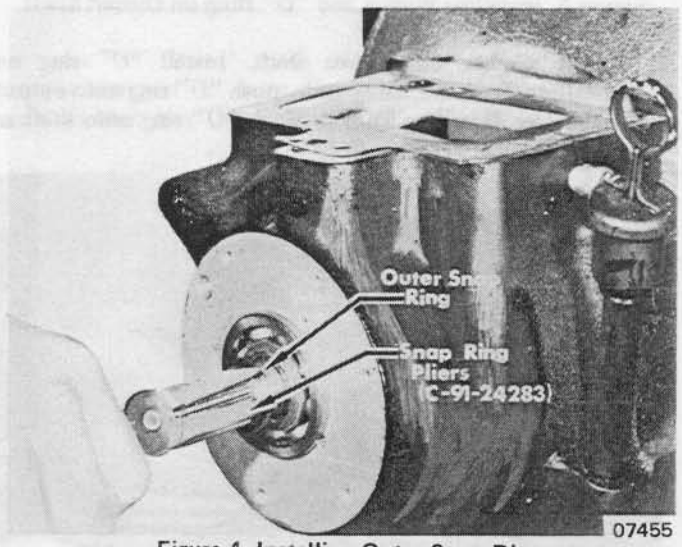


Figure 4. Installing Outer Snap Ring

5. Install planetary assembly in housing. Install inner snap ring, bearing (with number out) and outer snap ring. (Figure 4) Install bearing lubricating passage "O" ring. (Figure 5)

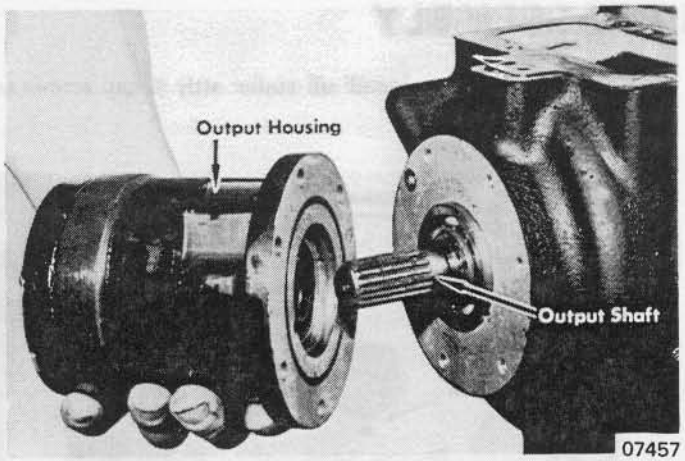


Figure 5. Installing Output Housing

NOTE: Install snap rings with sharp edges "away" from bearing. DO NOT drag snap rings on output shaft.

6. Install "O" ring in output housing and attach output housing with 6 cap screws and lockwashers. (Figure 5)

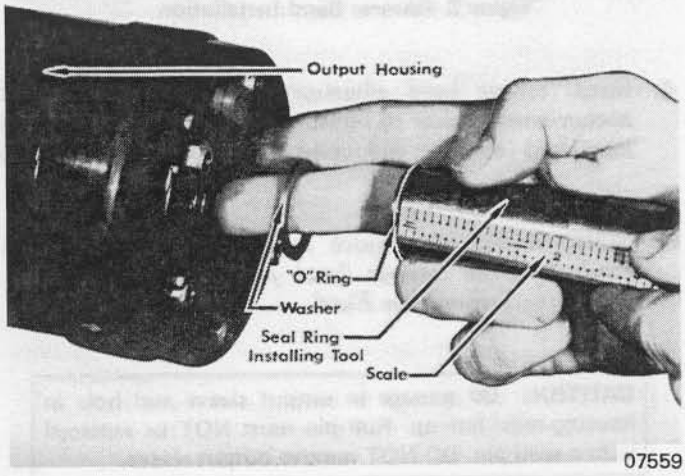


Figure 6. Installing Washer and "O" Ring on Output Shaft

7. Install washer on output shaft. Install "O" ring on Installing Tool and, using scale, push "O" ring onto output shaft. Use Installing Tool to work "O" ring onto shaft as far as it will go. (Figure 6)

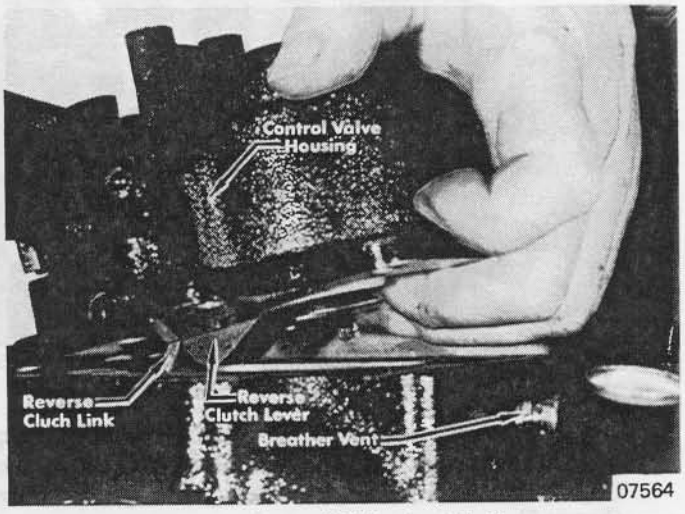


Figure 7. Control Valve Installation

8. Apply Multipurpose Lubricant (C-92-63250) to transmission control valve housing opening to hold new gasket and "O" rings in place. Install reverse clutch link into reverse clutch band. Hold control valve lever up into control valve housing and slide control valve housing onto transmission so that reverse band link and control valve lever mate. (Figure 7)

NOTE: Slot in clutch link must align with tang on reverse band.

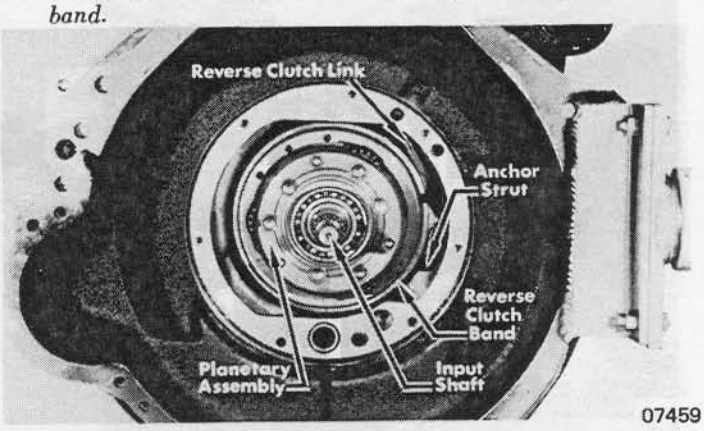


Figure 8. Positioning Reverse Clutch Link and Anchor Strut

9. Secure control valve with 7 cap screws. "J" clip is installed under cap screw closest to dipstick. Check inside transmission to make sure that clutch link, reverse band and anchor strut are in proper position. (Figure 8)
10. Install 4 "O" rings and pump housing in transmission. (Figure 9) Secure with 7 cap screws and new "O" ring washers.

NOTE: Two longer cap screws (5/16-18x1-3/8) are located as shown in Figure 9.

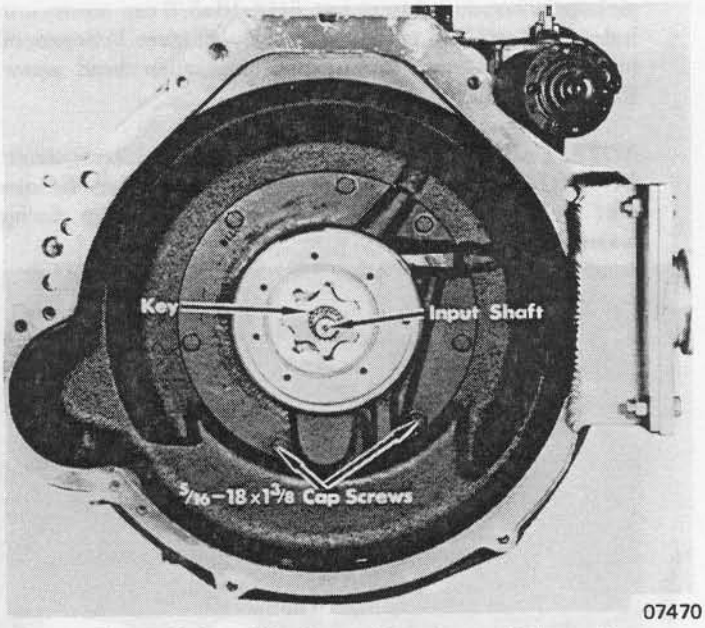


Figure 9. Installing Pump Housing and Elements

11. Position input shaft with keyway "up". Lubricate pump components with Automatic Transmission Fluid. Install new key, inner pump element and outer pump element. (Figure 9)

NOTE: When installing pump elements, align elements with grease pencil mark made in disassembly.

12. Install "O" ring and pump cover with 7 cap screws. (Figure 1 in "Disassembly")
13. Loosen locknut and torque reverse band screw to 120 in. lbs. (138kg-cm) (Figure 10) Back off 1-1/2 turns and

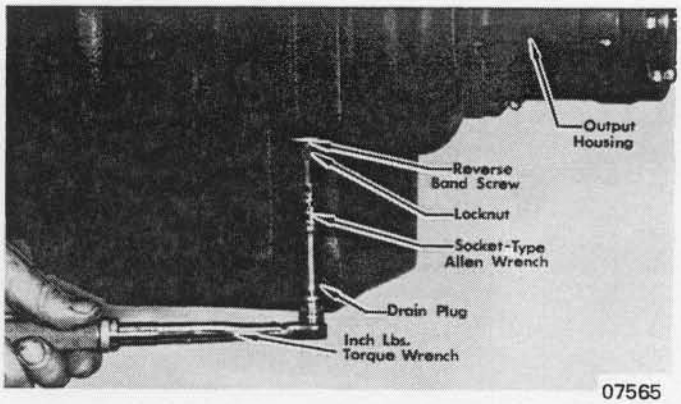


Figure 10. Adjusting Reverse Band

tighten locknut. Re-adjust reverse band screw after transmission has been run in reverse and forward for one minute.

14. Install reverse lock valve and actuating motor to motor bracket.
15. Lubricate assembly as follows: (Figure 11)
    a. Apply a liberal amount of Multipurpose Lubricant to completely fill space between end of motor housing and fork of output shaft.
    b. Also use Multipurpose Lubricant to fill space between cam for reverse lock valve and cover on transmission.
    c. Apply a coat of Anti-Corrosion Oil (C-92-63281) on area of reverse valve, as shown in Figure 11.
16. Install motor bracket (with actuating motor and reverse lock valve) onto control valve housing.

    NOTE: Ground wire from actuating motor must be attached to bracket cap screw.

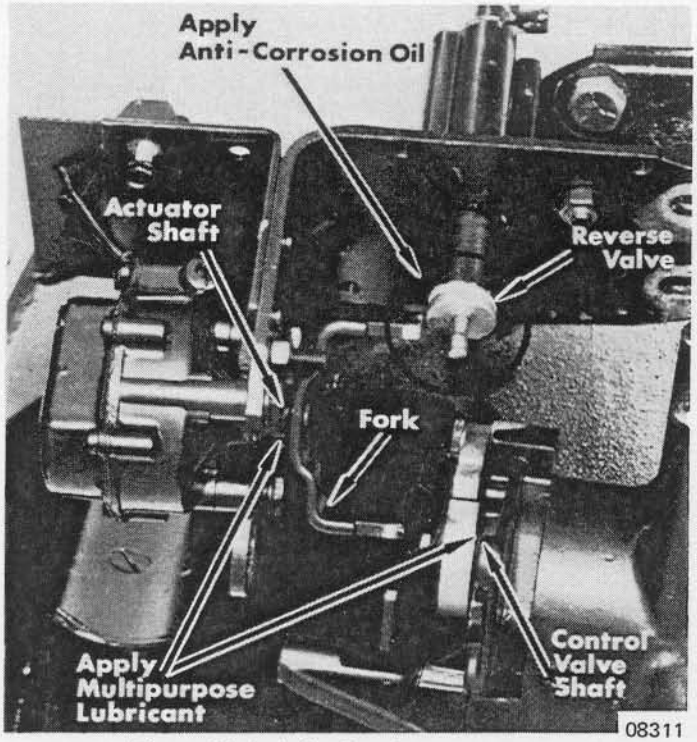


Figure 11. Lubricating Components

17. Install terminal strip and motor wires.
18. Install oil drain plug.
19. Fill transmission with 2 quarts of Automatic Transmission Fluid.

CAUTION: DO NOT mix types or brands of Automatic Transmission Fluid.

20. Install dipstick.

INSTALLATION

NOTE: Refer to "Specifications" Section 8 for torque specifications.

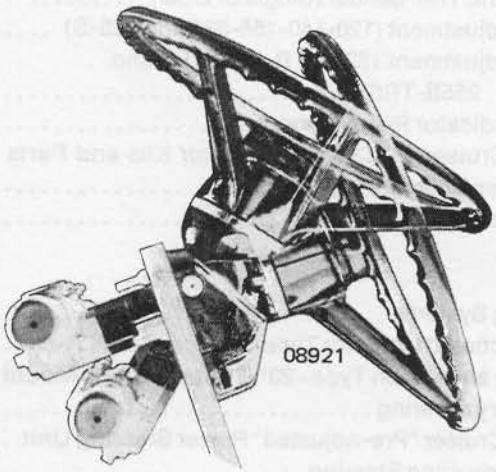
1. Lubricate transmission input splines with Multipurpose Lubricant (C-92-63250).
2. Align input splines with flywheel drive plate of engine. Push transmission ahead and on engine. Install 6 transmission attaching cap screws.
3. Attach cooler hoses to transmission cooler. (Figure 3 in "Removal")
4. Install dust cover and starter motor.
5. Attach yellow neutral start wire to terminal block on flywheel housing and yellow/black wire to starter solenoid.
6. Secure harness bracket to transmission. (Figure 2 in "Removal")
7. Attach hydraulic hoses to reverse lock valve.
8. Install shifting leads (Figure 2 in "Removal") and actuator cover.

   NOTE: If location of engine in boat does not permit re-adjustment of transmission reverse band after engine installation, engine should be test-run and reverse band should be adjusted before installing engine in boat. (Refer to "Specifications" Section 8.)

9. Install engine in boat. (Refer to Section 2J.)

   NOTE: If engine has not been test-run, then test-run and re-adjust reverse band. (Refer to "Specifications" Section 8.)

ACCESSORIES
MERCRUISER
Section 7



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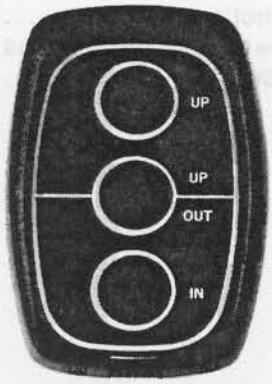

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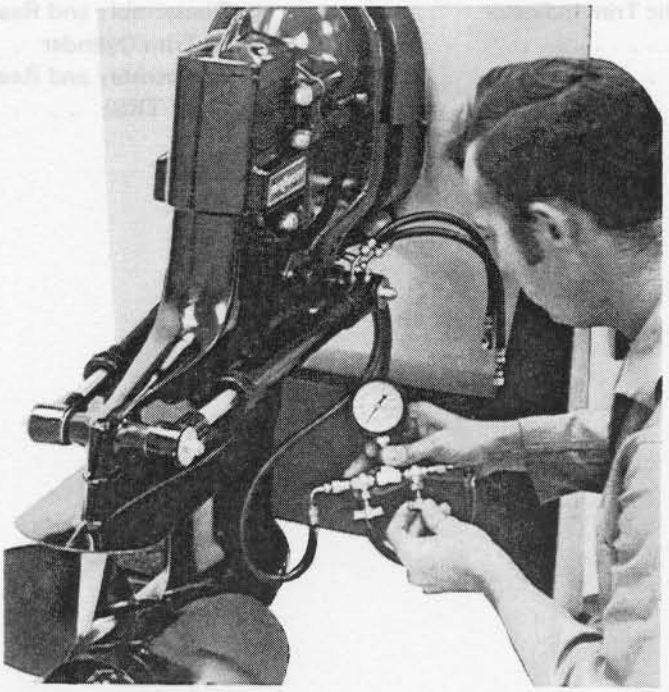
SECTION 7 - ACCESSORIES

MERCRUISER

PART A - POWER TRIM SYSTEM



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MERCURY MARINE

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POWER TRIM

DESCRIPTION

Power Trim hydraulic system consists of a combination of the following:

1. Hydraulic pump (includes a valve body gear assembly, control valve, pump motor and reservoir)
2. Trim cylinders
3. Reverse lock valve
4. Trim indicator sender
5. Associated hoses and fittings

TROUBLESHOOTING

Refer to Section 10, "Troubleshooting".

WIRING CONNECTIONS

Refer to Section 3E, "Wiring Diagrams".

LARGE RESERVOIR HYDRAULIC PUMP - HIGH PRESSURE

REMOVAL and INSTALLATION

1. Remove hydraulic hoses and electrical wiring from pump. Mark wires and hoses for ease in reassembly.
2. Remove mounting bracket bolts and remove pump.

DISASSEMBLY

CAUTION: Work area must be dirt-and-lint-free, since slightest amount of dirt in hydraulic system will cause pump malfunction.

1. Remove fill screw and drain oil.
2. Remove four 7/16" screws from control valve assembly.
3. Remove 8 flat head screws from valve body and gear assembly.
4. Separate reservoir from valve body. (Figure 1)

NOTE: Precision fitting of valves and gears requires that valve body and gear assembly must be replaced as a unit.

These hydraulic pumps have a small can set over inlet screen of valve body and gear assembly. Place can over inlet screen when reassembled.

REASSEMBLY

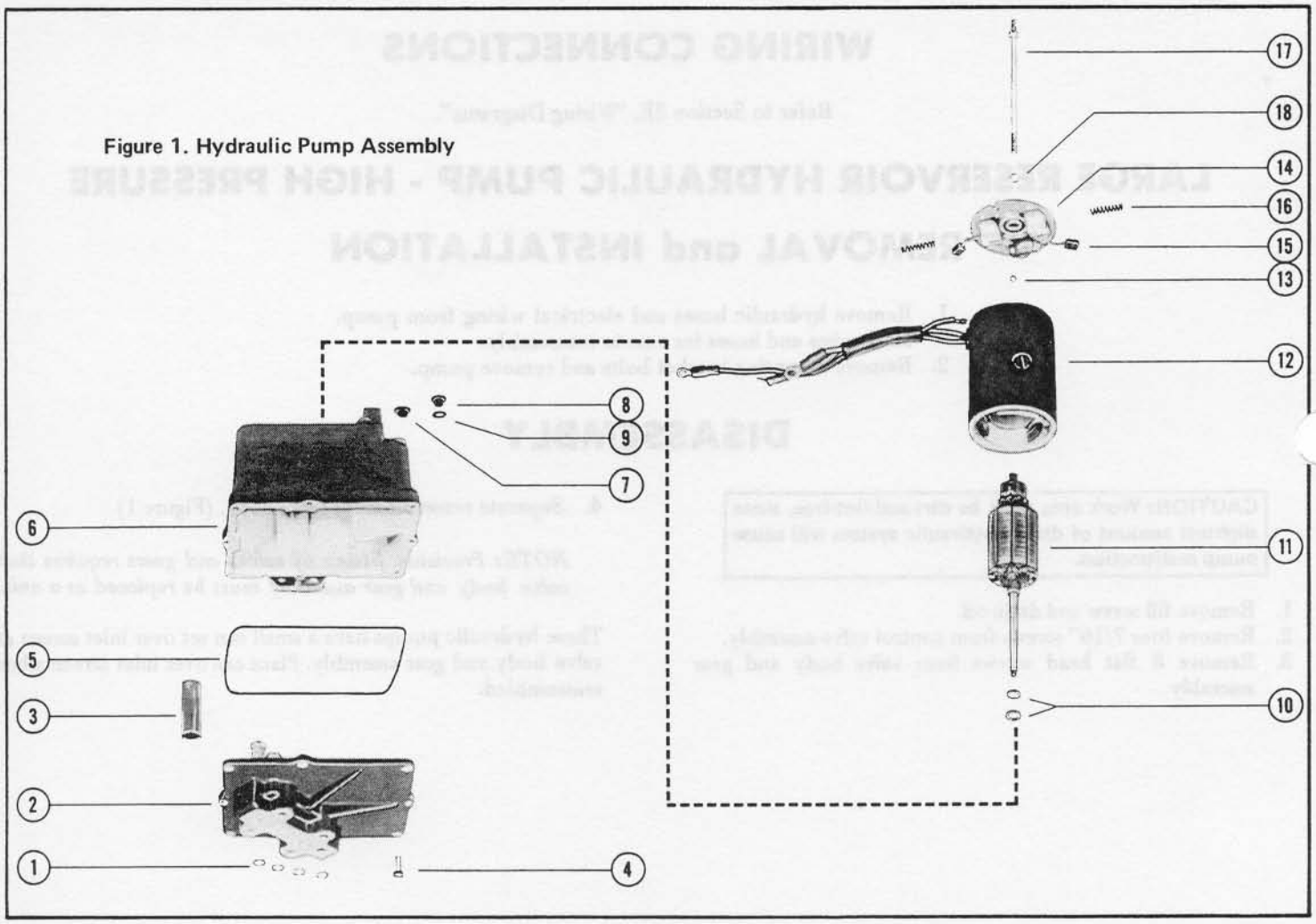
CAUTION: Work area must be dust-and-lint-free. Slightest amount of dirt will cause pump to malfunction.

1. Place small amount of Liquid Neoprene (C-92-25711) in seal groove of valve body and gear assembly to hold seal in place during installation.

CAUTION: Do not use Liquid Neoprene in excess or allow it to enter valve body and gear assembly.

2. Place valve body can over inlet screen. (Figure 1)
3. Replace seal on valve body and gear case assembly.
4. Install valve body and gear assembly to reservoir with 8 flat head screws, tightening evenly.
5. Place new "O" rings on control valve and install control valve to valve body and gear assembly with four 7/16" bolts, tightening evenly.
6. Place Liquid Neoprene around edges of housings to provide a seal. Allow to dry thoroughly and repaint.
7. To refill and bleed hydraulic system, refer to instructions under heading, "Bleeding Procedure", following.

Figure 1. Hydraulic Pump Assembly



1 - "O" Ring, hydraulic pump
2 - Valve Body and Gear Assembly
3 - Can, valve body
4 - Screw, valve body to reservoir
5 - Seal, reservoir to valve body and gear
6 - Reservoir Assembly
7 - Screw, vent - hydraulic pump
8 - Screw, filler - hydraulic pump
9 - Washer, sealing - filler screw
10 - Washer, thrust - armature
11 - Armature, field and frame
12 - Field and Frame Assembly
13 - Ball, commutator end plate
14 - Plate Assembly, commutator end
15 - Brush Set, commutator end plate
16 - Spring Set, brush tension
17 - Bolt Set, thru - plate and frame to reservoir
18 - Lockwasher, thru bolt

TESTING

HYDRAULIC PUMP TEST GAUGE (C-91-52915A3)

Field Test Procedures for Hydraulic System

NOTE: Refer to Service Manual Troubleshooting Charts (Section 10) to Help Diagnose Hydraulic System Problems.

TEST GAUGE CONNECTION (As Tested at Hydraulic Hose Connector)

FOR TESTING

A. Pump "Up" Pressure
B. Pump "Down" Pressure
C. Trail-Out Valve Pressure
D. "Reverse" Lock Valve Leak Check

NOTE: If hydraulic system is being tested with boat in water, hose connection and test procedure ("As Tested at Control Valve", following) must be used.

1. Disconnect 4 hydraulic trim cylinder hoses from gimbal housing hydraulic hose connector. (Figure 2)
2. Cap off all 4 hoses with caps supplied in test gauge parts bag.
3. Plug 2 hose connections on one side of hose connector. (Figure 2)
4. Install hydraulic pump test gauge hoses to hose connections on other side of connector. (Figure 3) Make sure that all hose connections and plugs are tightened securely and do not leak.
5. Check pump oil level. Add oil if necessary. Proceed with following test desired (MerCruiser Test "A", "B", "C" or "D", following).

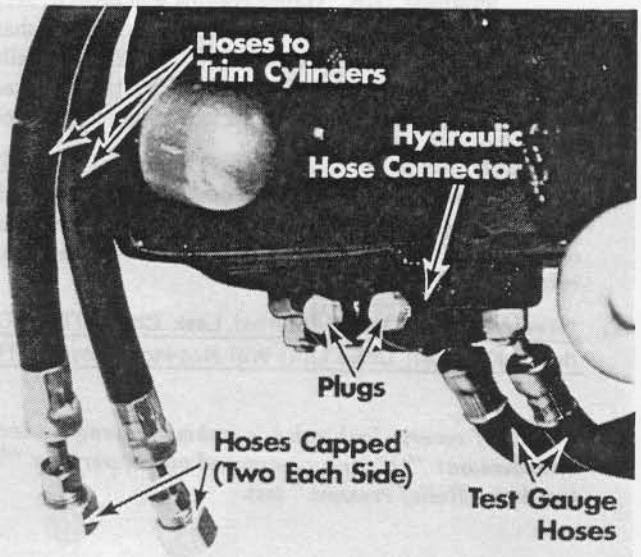


Figure 2. Hydraulic Hoses Capped

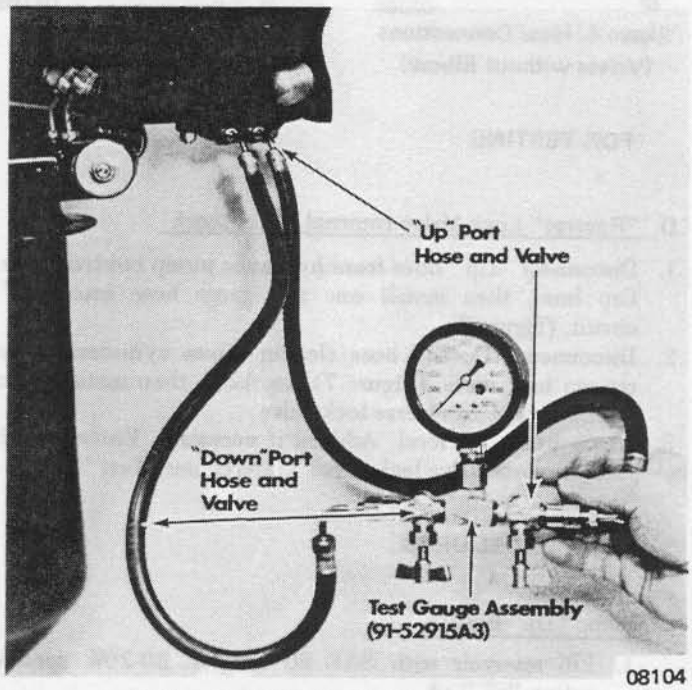


Figure 3. Hydraulic Test Gauge Installed

NOTE: Test gauge hose, connected to front hose connection on gimbal housing hose connector, will be referred to as "Up" port hose and valve. Test gauge hose connected to aft hose connection will be referred to as "Down" port hose and valve. (Figure 3)

TEST GAUGE CONNECTION (As Tested at Control Valve)

FOR TESTING

A. Pump "Up" Pressure
B. Pump "Down" Pressure
C. Trail-out Valve Relief Pressure

1. Remove and cap "Up" port and "Down" port hoses from control valve.
2. Connect test gauge hoses to control valve assembly as shown in Figures 4 or 5.

NOTE: Test gauge hose, connected to "Up" port, will be referred to as "Up" port hose and valve. Test gauge hose, connected to "Down" port, will be referred to as "Down" port hose and valve.

3. Check pump oil level. Add oil if necessary. Proceed with test desired (MerCruiser Test "A", "B" or "C").

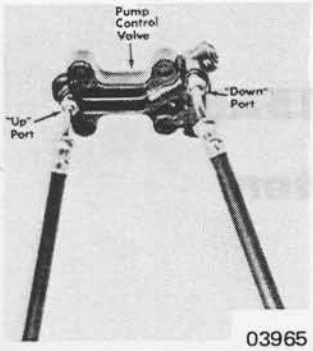


Figure 4. Hose Connections (Valves without Elbow)

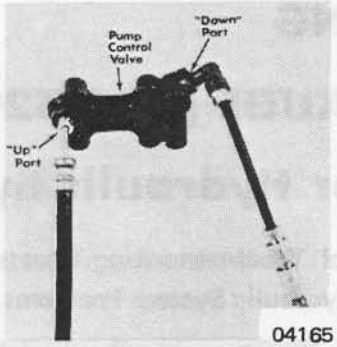


Figure 5. Hose Connections (Valves with Elbow)

FOR TESTING

D. "Reverse" Lock Valve Internal Leak Check

1. Disconnect "Up" hose from hydraulic pump control valve. Cap hose, then install one test gauge hose into "Up" circuit. (Figure 7)
2. Disconnect "Down" hose (leading from cylinders) from reverse lock valve. (Figure 7) Cap hose, then install other test gauge line to reverse lock valve.
3. Check pump oil level. Add oil if necessary. Proceed with "Reverse lock valve leak check" (MerCruiser Test "D").

TEST PROCEDURES

A. Pump "Up" Pressure

1. Fill reservoir with SAE 20 or SAE 20-20W specification "SE" oil.
2. Close "Down" port valve and open "Up" port valve.
3. Run pump in "Up" direction until pressure stops rising, as indicated on gauge. Pump output "Up" pressure should be 3000 PSI (211kg/sq. cm) minimum for new pumps (a reading of 2700-3000 PSI [189.8-211kg/sq. cm] can be expected from various pumps with some operating time).
4. Stop pumping "Up". Gauge pressure will drop slightly, then hold steady. After stabilizing, pressure must hold steady. Leakage indicates a poor or failed check valve in pump and may result in failure to hold a trimmed position while running.

B. Pump "Down" Pressure

1. Test control valves, as shown in Figures 4 and 5, as follows:
   a. Open "Down" port valve and close "Up" port valve.
   b. Run pump in "Down" direction and note gauge reading. Reading should be 650-750 PSI (45.7 to 52.7kg/sq. cm). Early models may read from 500-600 PSI (35.2 to 42.2kg/sq. cm).
2. Test control valve, as shown in Figure 6, as follows:
   a. Open "Down" port valve and slightly crack open "Up" port valve (1/8-turn or less) to allow small amount of oil flow.
   b. Run pump in "Down" direction and note gauge reading. Reading should be 125 PSI minimum.

IMPORTANT: Readings under 125 PSI (8.8kg/sq. cm) may indicate that "Up" port valve (on test gauge) is open more than 1/8-turn. Check this valve before replacing pump control valve.

NOTE: Readings in Step 1 and 2 are "regulated" systems "Down" pressure (not actual pump "Down" pressure).

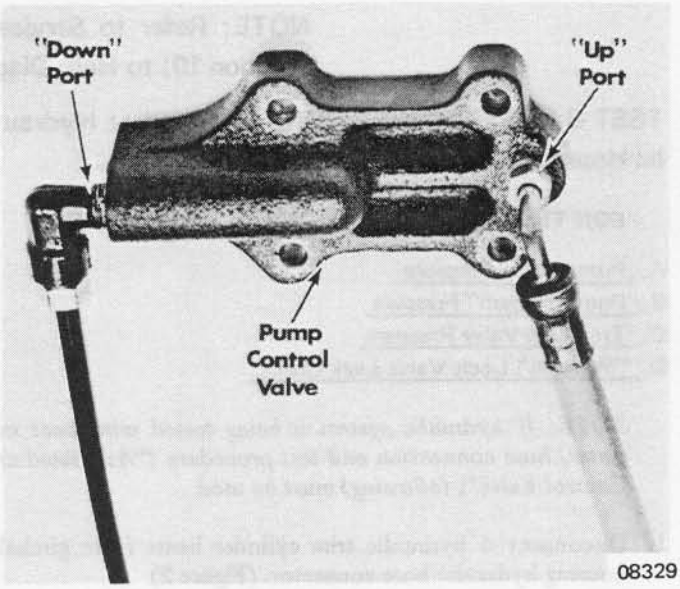


Figure 6. Low Pressure Control Valve

C. Trail-Out Valve Relief Pressure

1. Open "Up" port and "Down" port valves.
2. Run pump in "Up" direction and note gauge reading.
   a. Control valves (shown in Figures 4 and 5) reading should be 650-1100 PSI (45.7 to 77.3kg/sq. cm). Early models may read as low as 550-650 PSI (38.7 to 45.7kg/sq. cm). Stop pumping "Up". Gauge reading may stabilize between 100-400 PSI (7 to 28kg/sq. cm) or may continue to drop slowly to zero.
   b. Control valve (shown in Figure 6) reading should be less than 300 PSI (21.1kg/sq. cm). Stop pumping "Up". Gauge reading will drop to zero.
   c. If control valve (shown in Figure 6) has an Auxiliary Trim Valve Kit (B-71802A1) installed in system, pressure readings will be the same as for control valves shown in Figures 4 and 5, preceding.

NOTE: If pump fails any part of "Trail-Out Valve Relief Pressure" test, the oil is contaminated or control valve is defective. If gauge registers NO PRESSURE in Step 2, check pump "Up" pressure before replacing pump control valve.

D. "Reverse" Lock Valve Internal Leak Check (Trim Cylinders OK) When Drive Unit Will Not Hold Reverse Thrust

NOTE: If reverse lock valve is leaking externally, because of blown-out "O" ring or cracked cover, perform "Trail-Out Valve Relief Pressure" test.

1. Open "Up" port and "Down" port valves. (Figure 7)
2. Move reverse lock valve to closed position (shift into reverse), aligning marks.

3. Place a jumper lead between blue wire on terminal block on pump and blue lead on pump solenoid to by-pass the open reverse interlock switch.

CAUTION: DO NOT by-pass reverse interlock switch under any other circumstances. If switch is by-passed, and pump is run in "Up" direction, boosting action of cylinders will build hydraulic pressures which could damage cylinder and/or hydraulic lines.

4. Operate trim "Up". Pump pressure should be 2500-3500 PSI (175.8 to 246kg/sq. cm).

NOTE: If pressure is less than 2500 lbs., check pump "Up" pressure.

5. Close "Up" port valve and stop pump. (Figure 7) Gauge should remain steady. If pressure continues to drop, reverse lock valve assembly is defective or out-of-adjustment.

6. Remove jumper lead and shift drive unit into neutral gear.

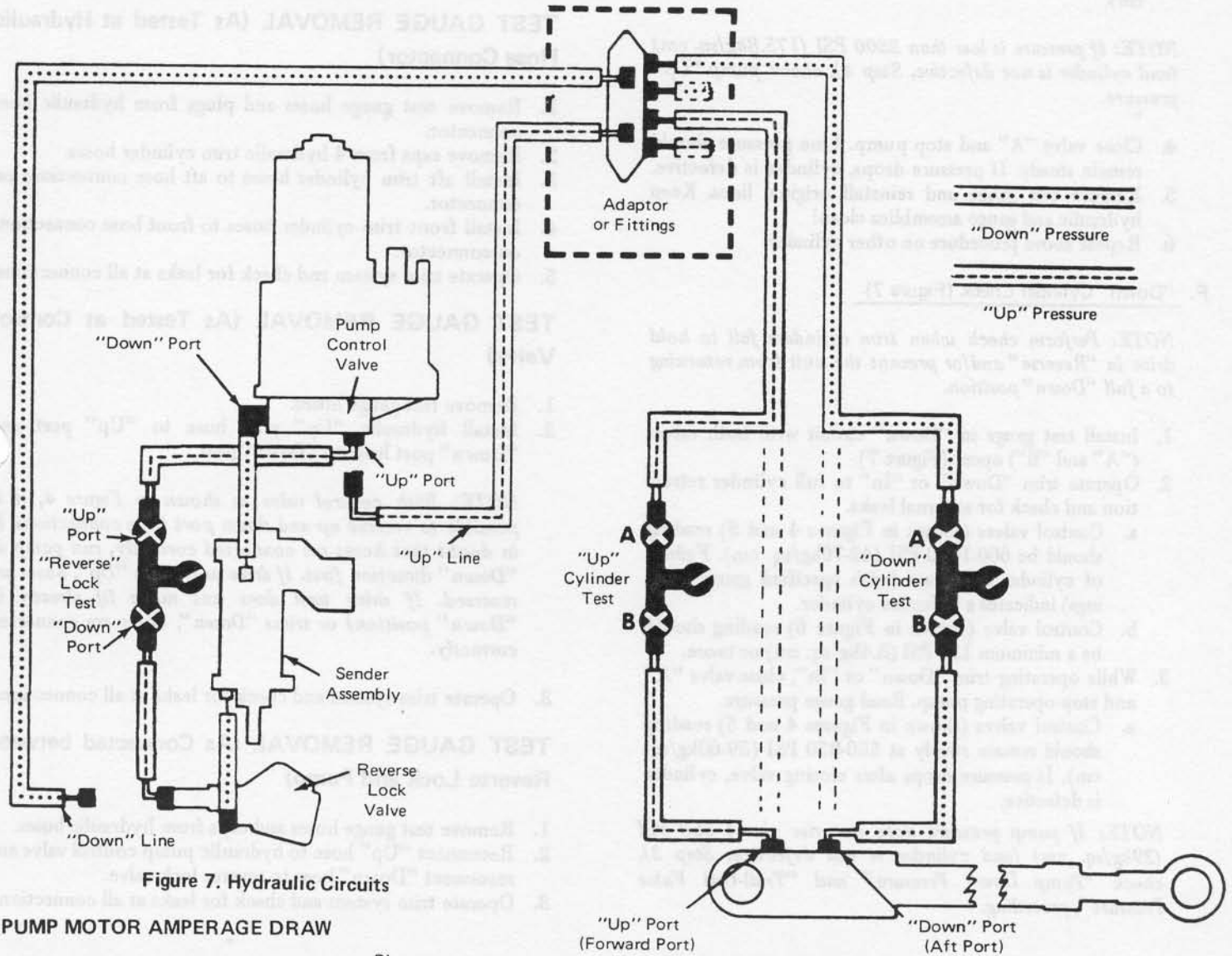


Figure 7. Hydraulic Circuits

PUMP MOTOR AMPERAGE DRAW

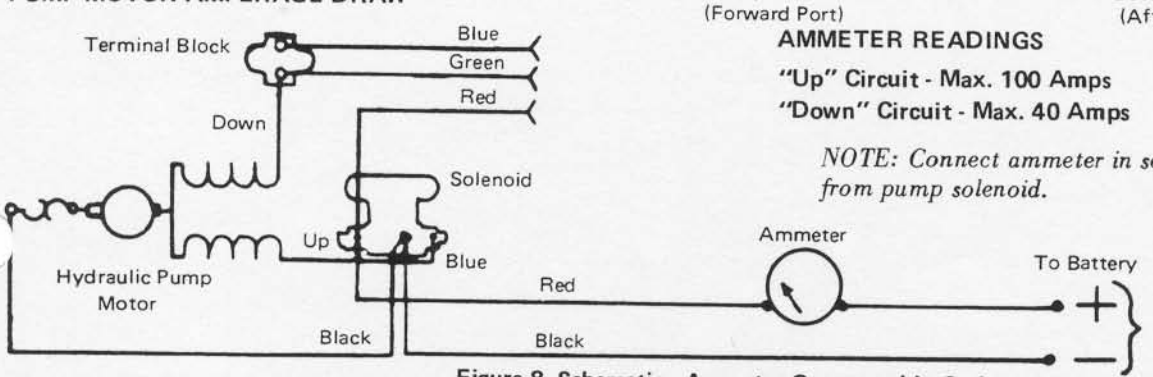


Figure 8. Schematic - Ammeter Connected in Series

AMMETER READINGS

"Up" Circuit - Max. 100 Amps

"Down" Circuit - Max. 40 Amps

NOTE: Connect ammeter in series with red lead to battery from pump solenoid.

E. "Up" Cylinder Check (Figure 7)

NOTE: Perform check when trim cylinders will not hold drive in "Trim" or "Up" positions. Purge air from lines before making connections.

1. Install test gauge in "Up" circuit with both valves ("A" and "B") open. (Figure 7)
2. Operate trim "Up" or "Out" to full cylinder extension and check for external leaks.
3. Read gauge pressure. Pressure should remain steady - approximately 2500-3000 PSI (175.8 to 246kg/sq. cm).

NOTE: If pressure is less than 2500 PSI (175.8kg/sq. cm) (and cylinder is not defective, Step 4), check pump "Up" pressure.

4. Close valve "A" and stop pump. Line pressure should remain steady. If pressure drops, cylinder is defective.
5. Remove test gauge and reinstall original lines. Keep hydraulic and gauge assemblies clean!
6. Repeat above procedure on other cylinder.

F. "Down" Cylinder Check (Figure 7)

NOTE: Perform check when trim cylinders fail to hold drive in "Reverse" and/or prevent the unit from returning to a full "Down" position.

1. Install test gauge in "Down" circuit with both valves ("A" and "B") open. (Figure 7)
2. Operate trim "Down" or "In" to full cylinder retraction and check for external leaks.
   a. Control valves (shown in Figures 4 and 5) reading should be 600-1000 PSI (42-70kg/sq. cm). Failure of cylinder to retract (with specified gauge readings) indicates a defective cylinder.
   b. Control valve (shown in Figure 6) reading should be a minimum 120 PSI (8.4kg/sq. cm) or more.
3. While operating trim "Down" or "In", close valve "A" and stop operating pump. Read gauge pressure.
   a. Control valves (shown in Figures 4 and 5) reading should remain steady at 550-850 PSI (39-60kg/sq. cm). If pressure drops after closing valve, cylinder is defective.

NOTE: If pump pressure does not rise about 550 PSI (39kg/sq. cm) (and cylinder is not defective, Step 3), check "Pump Down Pressure" and "Trail-Out Valve Pressure", preceding.

   b. Control valve (shown in Figure 6) reading should remain steady at minimum 75 PSI (5.3kg/sq. cm) or more.

NOTE: If pump pressure does not rise above 75 PSI (5.3kg/sq. cm) (and cylinder is not defective, Step 3) check "Pump Down Pressure" and "Trail-Out Valve Pressure", preceding.

4. Remove test gauge and reinstall original lines. Keep hydraulic and gauge assemblies clean.
5. Repeat above procedure on the other cylinder.

TEST GAUGE REMOVAL (As Tested at Hydraulic Hose Connector)

1. Remove test gauge hoses and plugs from hydraulic hose connector.
2. Remove caps from 4 hydraulic trim cylinder hoses.
3. Install aft trim cylinder hoses to aft hose connections on connector.
4. Install front trim cylinder hoses to front hose connections on connector.
5. Operate trim system and check for leaks at all connections.

TEST GAUGE REMOVAL (As Tested at Control Valve)

1. Remove test gauge hoses.
2. Install hydraulic "Up" port hose to "Up" port and "Down" port hose to "Down" port.

   NOTE: With control valve as shown in Figure 4, it is possible to reverse up and down port hose connections. If in doubt that hoses are connected correctly, run pump in "Down" direction first. If drive unit trims "Up", hoses are reversed. If drive unit does not move (if already in "Down" position) or trims "Down", hoses are connected correctly.

3. Operate trim system and check for leaks at all connections.

TEST GAUGE REMOVAL (As Connected between Reverse Lock and Pump)

1. Remove test gauge hoses and caps from hydraulic hoses.
2. Reconnect "Up" hose to hydraulic pump control valve and reconnect "Down" hose to reverse lock valve.
3. Operate trim system and check for leaks at all connections.

BLEEDING PROCEDURE - LARGE RESERVOIR BLACK PUMP

On units equipped with Power Trim, check the hydraulic system oil level periodically as follows:

1. Drive unit must be all the way down in normal operating position.
2. Remove "Fill" screw. (Figure 9)

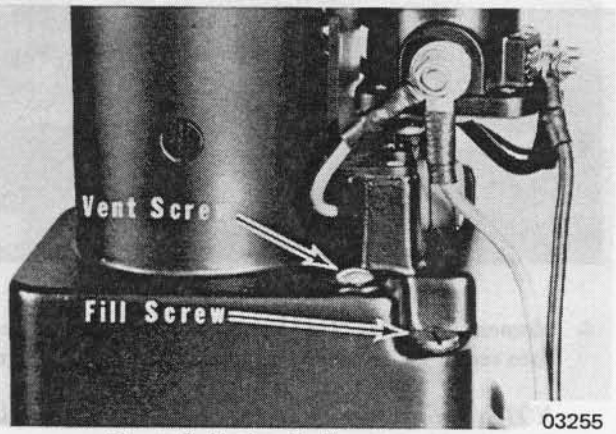


Figure 9. Hydraulic Pump

3. If oil level is low, fill pump to bottom of threads with SAE 20W "SE" oil. Do not over-fill.
4. Replace "Fill" screw.

Under normal conditions, Power Trim units are self-bleeding; however, in event of partial or complete loss of fluid, the system, necessarily, must be purged of air. Use the following bleeding procedure:

NOTE: Keep pump reservoir filled at all times with SAE 20W "SE" oil.

POWER TRIM CYLINDER BLEEDING PROCEDURE

BLEEDING "DOWN" SIDE of CYLINDER

1. With drive unit all the way down in normal operating position, disconnect aft end of cylinders from drive shaft housing and remove rear mounting pin.

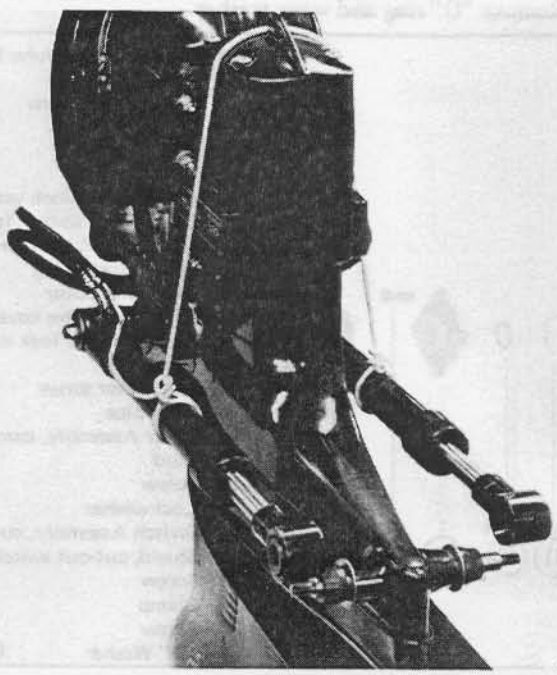


Figure 10. Cylinder Tied in Horizontal Position

2. Loop a length of rope thru lifting eye in top cover of drive shaft housing and tie each cylinder to hold in a horizontal position. (Figure 10)
3. Run hydraulic pump in "down" position until both piston rods are fully retracted. Check oil level of pump to be certain that it is full.
4. Disconnect aft hose on one cylinder and run pump in "up" direction. This will extend the piston rod and purge oil and air from the cylinder. (Figure 11)
5. Run pump in the "down" direction for a moment to purge any air in hose line to cylinder. When free of air, connect hose back to cylinder.
6. Repeat Steps "4" and "5" for the other cylinder.
7. Bleed "up" side of cylinder, following.

DO NOT overtighten hydraulic line fittings, or threads will be stripped out of tilt cylinders or pump hoses. Fittings should be "snugged up" until no leaking occurs at the fitting.

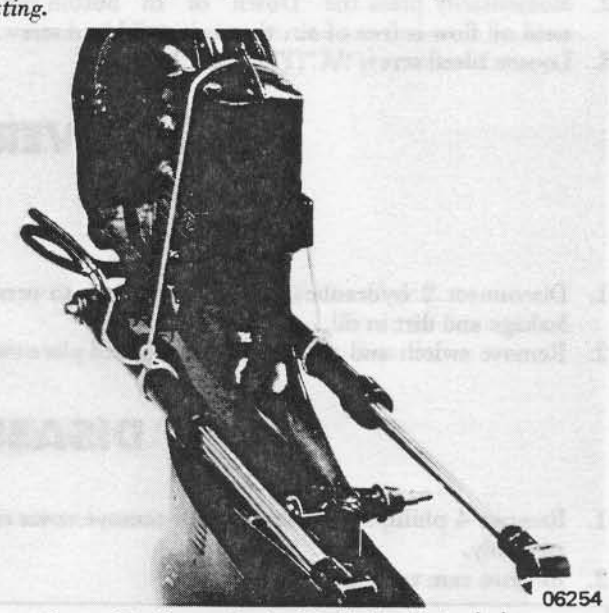


Figure 11. Piston Rod of Cylinder Extended

BLEEDING "UP" SIDE of CYLINDER (Following Bleeding "Down" Side of Cylinder)

1. Remove rope and allow cylinders to hang in near vertical position.
2. Run hydraulic pump in "up" direction until piston rods are fully extended.
3. Disconnect front hose on one cylinder and run pump in "down" direction. This will retract the piston and purge air and oil from the cylinder.
4. Run pump in "up" direction for a moment to purge any air in hose line to cylinder. When free of air, connect hose to cylinder.
5. Repeat Steps 4 and 5 for the other cylinder.
6. Reinstall cylinders to aft anchor pin.

ALTERNATE METHOD of BLEEDING AIR from CYLINDERS

1. Fill pump reservoir to proper level with cylinders retracted.

2. Remove cylinders from drive, then allow cylinders to hang down. This may be done with the boat in the water.
3. Operate the Power Trim system several times, extending and retracting the cylinders.
4. Position cylinders horizontally over drive anchor pin.
5. Operate the Power Trim system several times, extending and retracting the cylinders.
6. Reinstall cylinders. If air in cylinders is still apparent, bleeding procedure, preceding, must be followed.

BLEEDING PROCEDURE with TRIM INDICATOR ACCESSORY on MERCRUISER with HYDRAULIC TRIM INDICATOR SENDERS

NOTE: Air, that may have entered hydraulic system during indicator installation, will become trapped in the sender. The following "Bleeding Procedure" will not require bleeding the system at the cylinders.

1. Loosen bleed screw "B". (Figure 12)
2. Momentarily press the "Down" or "In" button and repeat until oil flow is free of air, then reinstall bleed screw.
3. Loosen bleed screw "A". (Figure 12)

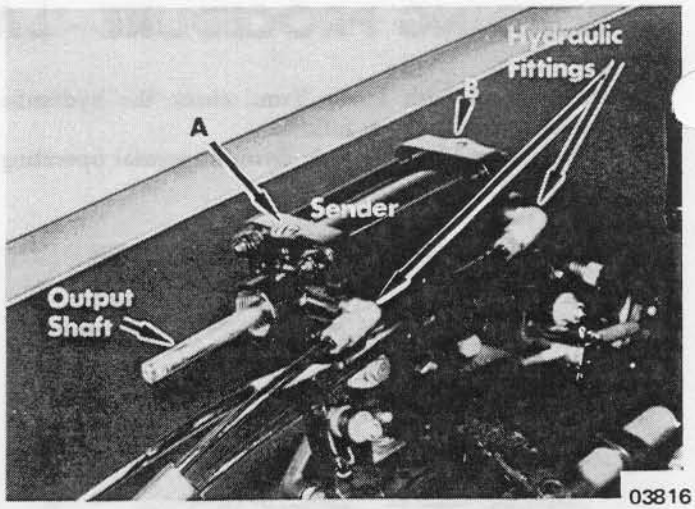


Figure 12. Bleed Screw Locations

4. Momentarily press "Up" button until oil flow is free of air, then reinstall bleed screw and add oil to pump reservoir.

NOTE: Be cautious not to lose "O" ring seals when removing bleed screws.

REVERSE LOCK VALVE

REMOVAL

1. Disconnect 2 hydraulic lines and cap lines to prevent oil leakage and dirt in oil.
2. Remove switch and switch wire clamp and place switch to the side.
3. Remove 2 nuts and remove shift lever.
4. Remove 2 screws and remove reverse lock valve.

DISASSEMBLY (Figure 1)

1. Remove 4 phillips head screws and remove cover and cam assembly.
2. Remove cam to cam lever screw.

CAUTION: Do not lose ball bearings.

3. Remove "O" ring and wave washer.

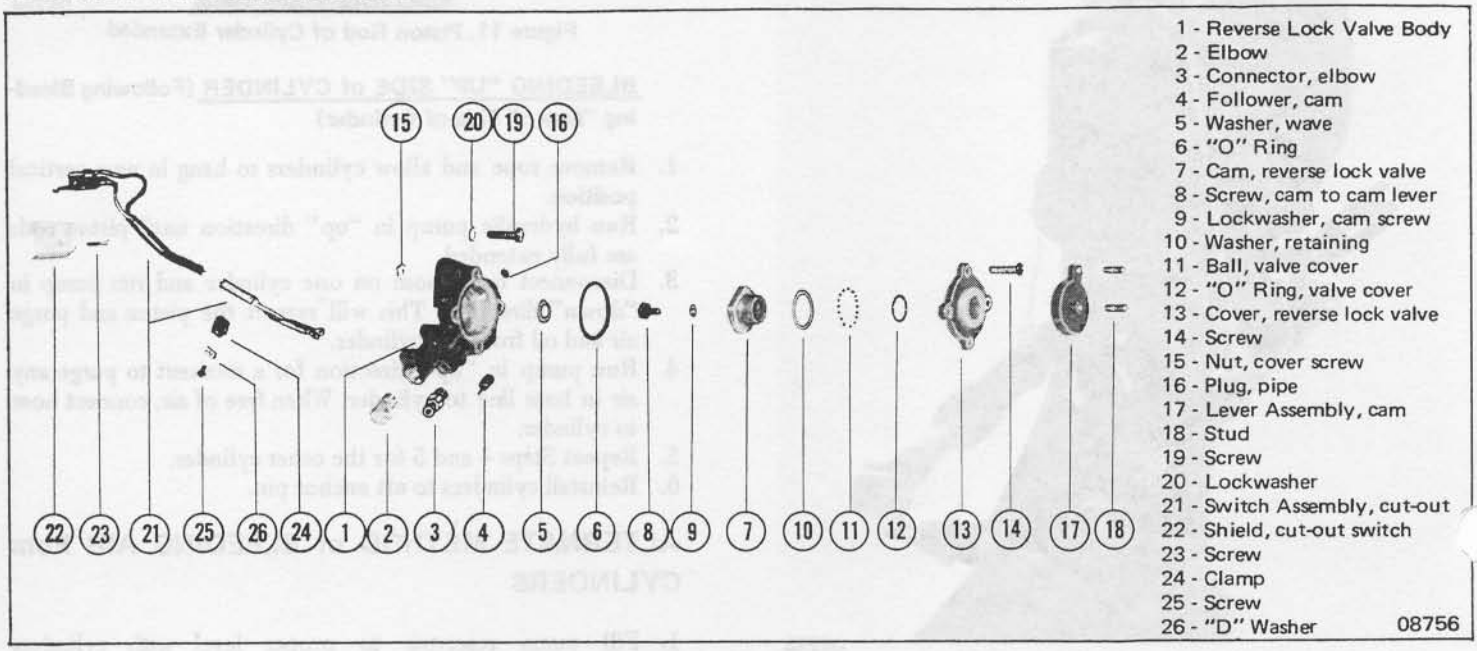


Figure 1. Exploded View - Reverse Lock Valve

INSPECTION and CHECKS

1. Check for broken or damaged parts.
2. Replace "O" rings.
3. Check operation of switch by using Continuity Meter or Test Lamp (if applicable), as follows:
   a. Attach test lead to each switch lead.
   b. Operate switch and note reading.
   c. Meter should indicate meter movement or lamp lights on one reading (switch in normal position), and NO meter movement or test lamp should NOT light on other reading (with switch operated). If both readings indicate meter movement or lamp lights or, if both readings indicate no meter movement or lamp does not light, replace switch.

REASSEMBLY

1. Attach cam, retaining washer, ball bearings and "O" ring to cover with lockwasher and screw.
2. Install wave washer and "O" ring into valve body and install cover assembly to body assembly with 4 phillips head screws.
3. Install valve assembly to engine.
4. For adjustment procedure, refer to Section 2, "Removal, Installation and Alignment".

   NOTE: If reverse lock valve leaks, or "O" ring comes out of valve, replace valve assembly.

REVERSE LOCK VALVE LEAK CHECK
(Using Hydraulic Pump Test Gauge C-91-52915A3)

Reverse Lock Valve (with CUT-OUT SWITCH) Internal Leak Check (Trim Cylinders OK) When Drive Unit Will Not Hold Reverse Thrust

NOTE: If reverse lock valve is leaking externally, because of blown-out "O" ring or cracked cover, perform "trail-out" valve relief pressure test.

1. Open "Up" port and "Down" port valves.
2. Move reverse lock valve to closed position (shift into reverse), aligning marks.
3. Place a jumper lead between blue wire on terminal block on pump and blue lead on pump solenoid to bypass the open reverse interlock switch.

CAUTION: DO NOT bypass reverse interlock switch under any other circumstances. If switch is bypassed, and pump is run in "Up" direction, boosting action of cylinders will build hydraulic pressures which could damage cylinder and/or hydraulic lines.

4. Operate trim "Up". Pump pressure should be 2700-3500 PSI (190-246kg/sq.cm).

   NOTE: If pressure is less than 2700 PSI, check pump "Up" pressure.

5. Close "Up" port valve and stop pump. Gauge should remain steady. If pressure continues to drop, reverse lock valve assembly is defective or out-of-adjustment.
6. Remove jumper lead and shift drive unit into neutral gear.

Reverse Lock Valve (without CUT-OUT SWITCH) Internal Leak Check (Trim Cylinders OK) When Drive Unit Will Not Hold Reverse Thrust

NOTE: If reverse lock valve is leaking externally, because of blown-out "O" ring or cracked cover, perform "Trail-Out Valve Pressure" test, preceding.

1. Install test gauge.
2. Open "Up" port and "Down" port valves.
3. Move reverse lock valve to closed position (shift into reverse), aligning marks.
4. Operate trim "Up". Pump pressure should be 2700-3300 PSI (190-231kg/sq.cm). If pressure is less than 2700 PSI, check pump "Up" pressure; if over 3300, replace reverse lock valve.
5. Close "Up" port valve and stop pump. Gauge should remain steady. If pressure continues to drop, reverse lock valve assembly is defective or out-of-adjustment.
6. Shift drive unit into neutral, remove test gauge and reconnect hydraulic lines.

CHECKING OIL LEVEL

On units equipped with Power Tilt or Power Trim, check hydraulic system oil level periodically as follows:

1. Drive unit must be all-the-way down in normal operating position.
2. Remove "Fill" screw. (Figure 2)
3. If oil level is low, fill pump to bottom of threads with "SE" rated 5W30 oil (or 30W in warm climates). Do not overfill.
4. Reinstall "Fill" screw.

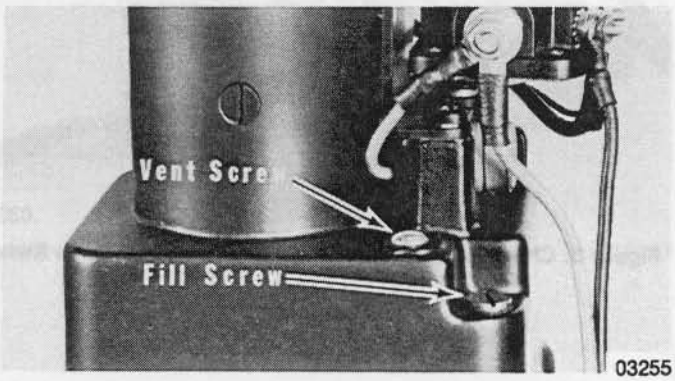


Figure 2. Hydraulic Pump

PUMP MOTOR
DISASSEMBLY and TESTING

1. Remove 2 screws from top of motor and reservoir assembly.
2. Separate reservoir and motor.
   a. Scribe a mark on housings to assist in reassembly.
   b. Be cautious not to lose spacer from armature. (Figure 1, Page 7A-2)
   c. Be cautious not to lose ball from commutator end plate. (Figure 1, Page 7A-2)
3. Pull armature out of frame and field assembly.
4. Check and clean armature as follows:
   a. If commutator is worn, it can be turned down on an armature conditioner tool or on a lathe. Mica must be undercut after reconditioning.
   b. If not worn badly, clean armature with "OO" sandpaper.
   c. Check armature on a growler. (Follow growler manufacturer test instructions.) Any indication of shorts or open windings requires replacement of armature.
5. Remove upper end cap from frame and field assembly.
6. Inspect condition of brushes. Replace, if pitted or worn to one-half original length.
7. Replace brush as follows:

   NOTE: Standard rosin core solder cannot be used for brush replacement, as it would interfere with thermal cut-out switch.

   a. Cut old brush shunt at brush box and solder a new brush shunt with high temperature solder. This solder preferably should have a high tin content and some silver with melting point around 500°F+ (260°C+). Since silver solder generally requires use of a torch, care should be taken not to burn motor insulation.
   b. Insulate soldered connection with a heat-shrink type sleeve.

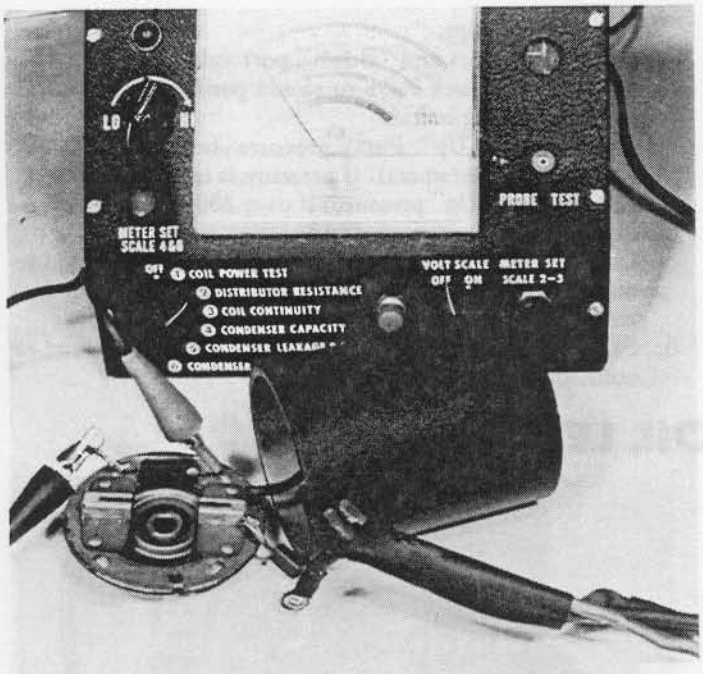


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Figure 3. Checking between Brush Pigtail and Thermal Switch

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Figure 4. Checking between Brush Holders and End Cap

8. Clean and inspect end cap.
   a. Check thermal switch for resistance. Check between brush pigtail and opposite end of thermal switch. (Figure 3) If thermal switch indicates high resistance, replace end cap.
   b. Check between brush holder and end cap for shorts (Figure 4) and between brush pigtail and end cap.

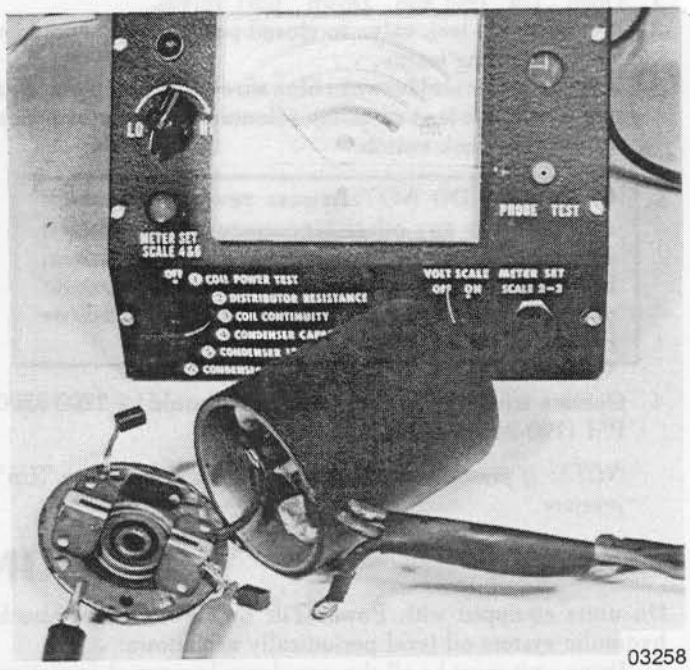

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Figure 5. Checking between Brush Pigtail and End Cap

(Figure 5) Use Continuity Meter or Test Lamp with one test lead connected to end cap and other test lead connected to brush holder or brush pigtail. (Figures 4 and 5) Meter should indicate NO meter movement,or Test Lamp should NOT light.

9. Clean and inspect frame and field assembly.
   a. Use ohm meter and -
      (1) Check for resistance between green wire and black jumper wire. (Figure 6)
      (2) Check for resistance between blue wire and black jumper wire.
      (3) Check black ground wire for resistance.
      (4) High resistance on any of the preceding checks requires replacement of frame and field assembly.
   b. Use Continuity Meter or Test Lamp and check for short between black jumper wire and frame. If indicator needle moves or lamp lights, a short between field and frame exists, and replacement is required.

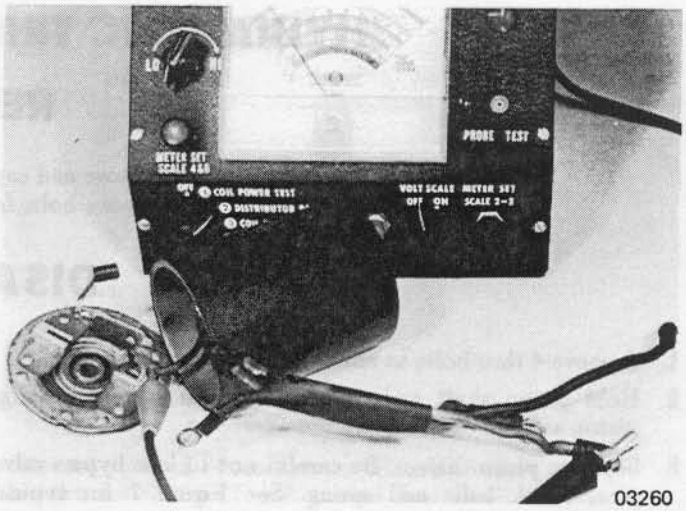

Figure 6. Checking between Green Wire and Black Jumper Wire

REASSEMBLY

CAUTION: Work area must be dust-and-lint-free. Slightest amount of dirt in hydraulic system will cause pump malfunction.

1. Install armature into frame and field assembly.
2. Install upper end cap assembly.
   a. Depress brushes into holders and slide over commutator bars.
   b. Do not chip or mar brushes.
3. Install screws into cap, including ground wire under one screw.

HYDRAULIC TRIM INDICATOR SENDER

REMOVAL

1. Remove and cap hydraulic hoses.
2. Remove bolts from bracket and remove sender.

DISASSEMBLY

1. Remove 4 thru bolts to remove end caps and piston.
2. Hold piston shaft end, remove nut and washer and slip piston assembly from shaft.
3. Separate piston halves. Be careful not to lose bypass valve pins, check balls and spring. See Figure 7 for typical assembly.

IMPORTANT: Keep all parts clean. Work in a clean area. Lubricate parts during assembly with type "SE" 20W oil.

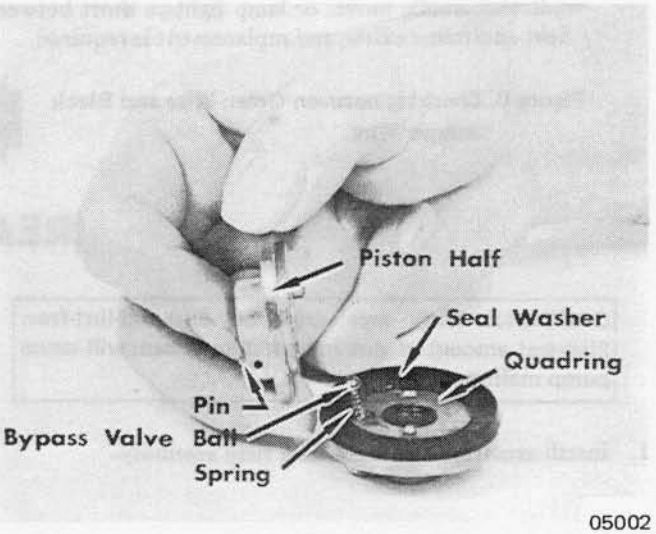

Figure 7. Typical Piston and Valve Parts

REASSEMBLY

1. Place new seal washer and quadring on piston half and reassemble piston on shaft, being careful to replace bypass valve parts. (Figure 8) Tighten nut securely.
2. Pick "O" ring from shaft side end cap (being careful not to disturb staked washer) and install new "O" ring. (Figure 9)

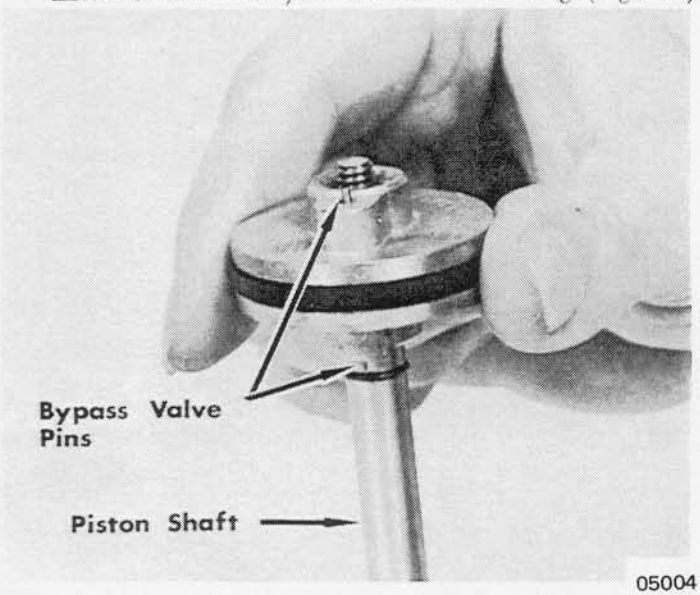

Figure 8. Typical Piston Shaft Assembly

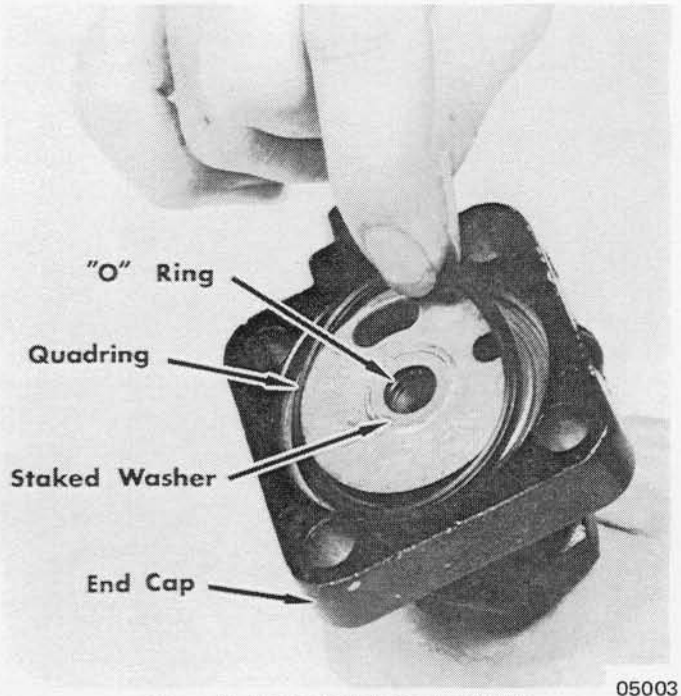

Figure 9. Typical End Cap Assembly

3. Install new quadrings in both end caps.
4. Reassemble sender and tighten thru bolts securely. This completes sender reassembly.

CHECKING LINEAR-TYPE POWER TRIM INDICATOR

NOTE: Be sure that Power Trim system is free of air before proceeding with following check. (Refer to "Bleeding Procedure"; use "Index".)

HYDRAULIC

1. Remove electric sender from hydraulic sender.
2. Operate trim "in" and "out" while observing piston shaft extend and retract. Shaft should move smoothly with respect to trim cylinder movement. If piston shaft has erratic movement, binds or will not move, repair hydraulic sender. (Refer to "Hydraulic Trim Indicator Sender", preceding.)
3. If indicator needle moves to "Trim Out" position WITHOUT trim cylinder moving, complete the following:
   a. Follow "Trim Indicator Gauge" and "Trim Indicator Sender", following.
   b. If electrical system checks good, watch sender piston shaft while boat is underway. If, after a time, piston shaft retracts or can be pushed in with very light finger pressure, repair hydraulic sender. (Refer to "Hydraulic Trim Indicator Sender", preceding).
4. If indicator needle moves to "Trim Out" position with trim cylinders moving "in", complete the following:
   a. Follow "Trim Indicator Gauge" and "Trim Indicator Sender", following.
   b. If electrical system checks good, trim cylinder has an internal leak. (Refer to "Testing: Cylinder Checks"; see "Index".)

ELECTRICAL

Remove sender and connect sender leads to VOA Tester (C-91-52751) (R x 1 scale). Push sender plunger in with pencil or similar object and note meter reading. Sender resistance should be approximately between zero and 160 ohms. If erratic or no needle movement is noted, replace and adjust new sender.

CHECKING ROTARY-TYPE TRIM INDICATOR

ELECTRICAL

1. Connect ohmmeter to sender leads.
2. Operate trim system while watching ohmmeter. Meter should indicate even movement from zero to about 160 ohms (zero to about 80 ohms on dual station senders).
3. If movement is erratic, or if there is no meter movement, remove sender from gimbal ring and operate manually, again checking ohm readings. If still erratic or no movement is indicated on ohmmeter, replace sender and adjust new sender. If proper meter movement is found when testing with sender removed from gimbal ring, proceed with "Mechanical" test, following.

MECHANICAL

1. If erratic or no meter movement is noted with sender installed, and correct meter movement is noted with sender removed, observe hinge pins while unit is trimmed up-and-down (with trim sender still removed).
2. Hinge pin should move with bell housing assembly. If hinge pin does not move with bell housing, it must be lubricated according to instructions in Section 6, "Drive Unit".

POWER TRIM SENDER ADJUSTMENT

ADJUSTMENT - LINEAR TYPE

1. Operate drive trim system fully to "Up", then "Down" positions. Hold in button until sender rod is fully extended (Figure 1) and trim cylinders are fully retracted.
2. Connect sender leads to connector block on engine.
3. Turn ignition key to "On" position.

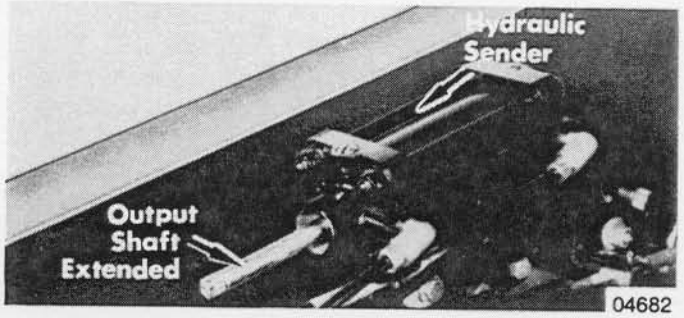

Figure 1. Output Shaft Extension

4. Thread on electric sender (Figure 2) until panel indicator pointer is at bottom of green arc. (Figure 3)

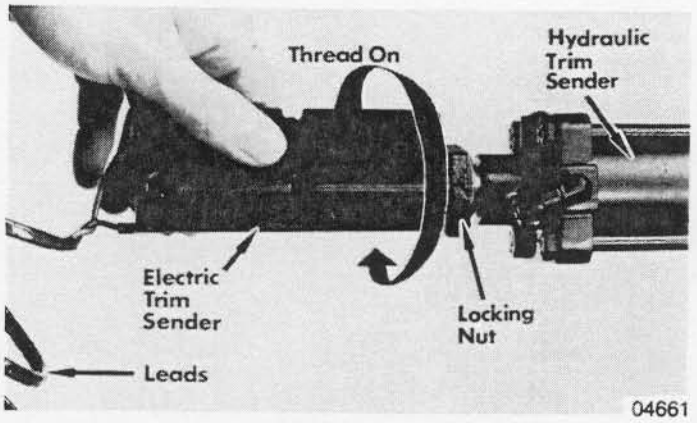

Figure 2. Threading Electric Sender

NOTE: Hydraulic tubing and fitting were removed from hydraulic sender in Figure 2 for clarity.

5. Tighten locking nut and turn off key switch.
6. Disconnect wiring to straighten leads, then reconnect.

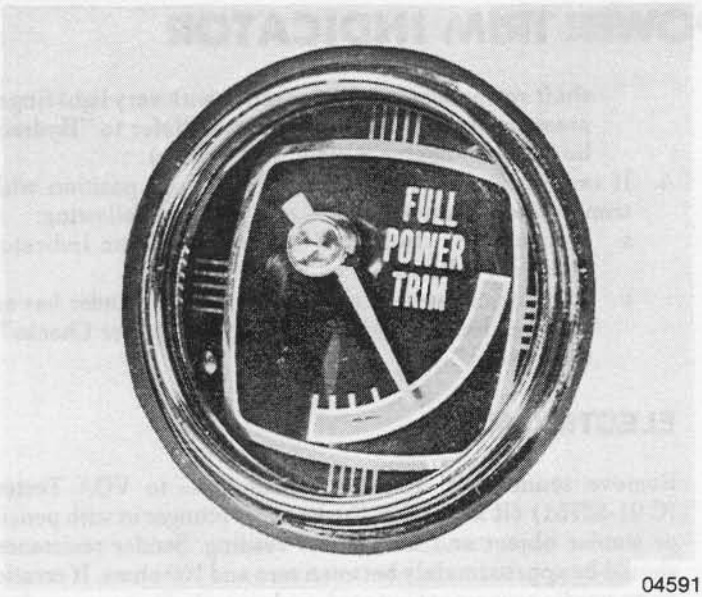

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Figure 3. Panel Indicator Pointer

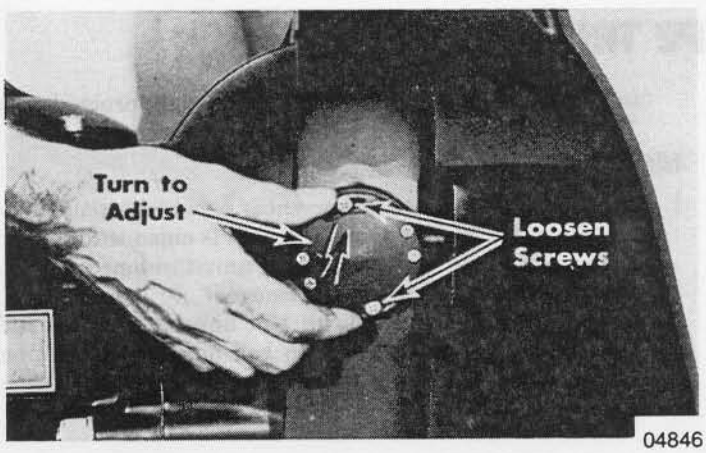

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Figure 4. Adjusting Trim Sender Switch

ADJUSTMENT - ROTARY TYPE

The following procedure is for fine adjustment of instrument needle to bottom of green arc on instrument face.

1. Turn stern drive hard to left (port) in the full "Down" trim position.
2. Loosen 2 adjusting screws (Figure 4) which hold Indicator Sender.
3. Turn ignition key to run position.
4. Rotate Indicator Sender housing in either direction (Figure 4) to show indicator instrument needle on bottom of green arc. (Figure 3)
5. Tighten adjusting screws, check instrument reading and turn ignition key to "off" position.

INDICATOR READJUSTMENT

If unit (with linear sender) was fully extended into trailer position, it may be necessary to synchronize the indicator by operating "In" button. Hold "In" button until trim cylinders fully retract.

TRIM INDICATOR GAUGE

NOTE: Before proceeding with following checks, check all terminals and connections for looseness and corrosion. Check wiring for open circuit. Refer to "Section 3, Electrical System Part E" for wiring diagrams.

1. Remove leads from gauge terminals.
2. Connect jumper lead from red lead on ignition switch terminal to "IGN" terminal on gauge. Gauge needle should deflect beyond red arc.
3. Without removing jumper lead, ground other gauge terminal to gauge case. Gauge needle should deflect back slightly past green arc.

MERCRUISER TRIM CYLINDER
REPAIR KITS and PARTS REPLACEMENT
DISASSEMBLY and REASSEMBLY

CAUTION: Work in clean, lint-free area. Lubricate parts with 20W "SE" rated oil after cleaning.

NOTE: Disregard Steps 1, 2, 17, 18 and 19, if pivot end is not to be replaced.

1. Secure piston rod in vise (with soft jaws to prevent possible scoring) as close to pivot end as possible. (Fig. 5)

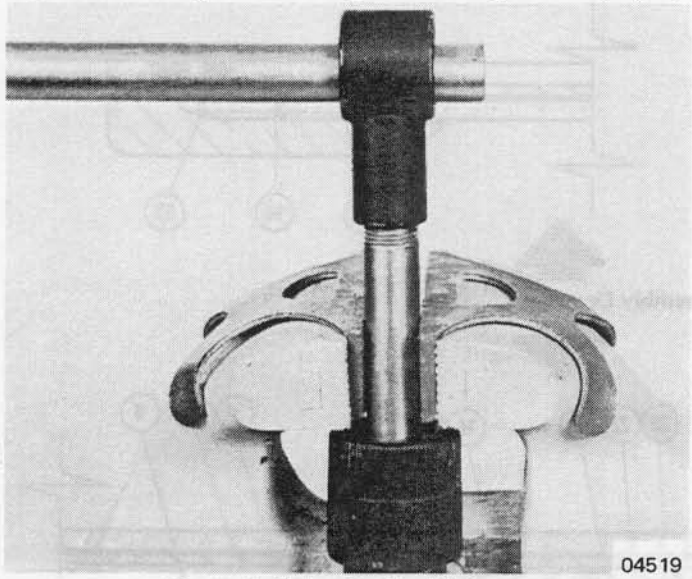


Figure 5. Piston Rod in Vise

2. Place a bar thru eye of pivot and rotate counterclockwise to remove. If pivot end is extremely tight, apply heat only with piston rod extended, being careful not to overheat cylinder parts.

Figure 6. Removing End Cap

3. Rotate cylinder end cap carefully, counterclockwise with a pipe wrench to remove. (Figure 6)
4. Pull piston rod and piston rod bearing from cylinder. The inner cylinder can come with it.
5. Remove trim piston and tube guide. Use a wire hook to remove tube guide, if it remains in outer cylinder.

CAUTION: DO NOT remove or discard piston assembly if other than a major overhaul kit is used for repairs.

6. Place piston rod in vise, as in Step 1, and remove nut that retains piston assembly.
7. Remove piston assembly from piston rod and discard.
8. Remove piston rod bearing. Replace its inner and outer "O" rings.
9. Place plain washer, Equi-Flex scraper and piston rod bearing on piston rod.
10. Discard loose small shim washers in envelope. Use shim washers supplied with new piston only. Remove nut which holds new piston assembly together, being careful to hold assembly parts in position with a free hand.
11. Remove shipping bolt and washer from under piston head while holding piston upright. Place sealing washer in its proper piston upright. Refer to assembly drawing below. (Figure 7)

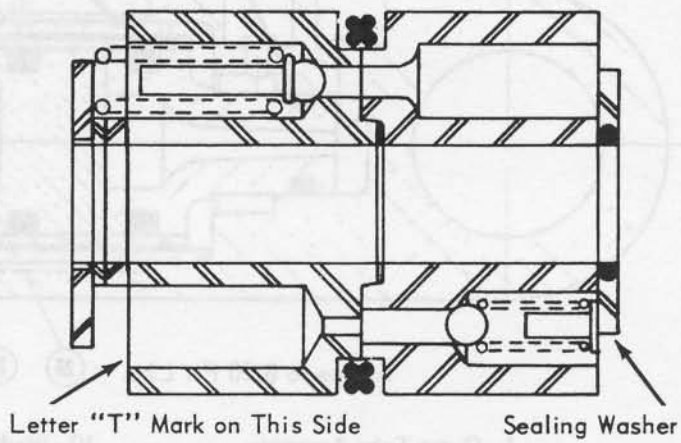


Figure 7. Piston Sealing Washer Location

12. Carefully place piston assembly over piston rod with sealing washer toward piston rod.
13. Install new nut and torque to 8-10 ft. lbs. (1.1-1.4mkg). Remove piston rod assembly from vise.
14. Place new "O" rings on floating piston and tube guide. Place them into inner cylinder and position them in the outer cylinder. Refer to assembly drawing. (Figure 8)
15. Insert piston rod and piston into inner cylinder while fitting piston rod bearing into outer cylinder.
16. Coat threads of outer cylinder with Perfect Seal (C-92-34227) and install end cap. Torque to 35-45 ft. lbs. (4.8-6.2mkg).
17. Secure piston rod in vise as close to pivot end threads as possible. (Figure 5)

18. Clean threads on piston rod and apply Loctite (C-92-36088).
19. Replace pivot end and torque to 25-30 ft. lbs. (3.5-4.2mkg).
20. Paint over scratches to protect exposed metal.
21. After installation of these kits (B-45522A3 or C-25-60342A2), the repaired cylinder MUST BE MARKED with an "X" permanent stamp on the trim cylinder piston rod near the pivot end (if not already marked in this manner). (Figure 6)

NOTE: The letter "X" indicates that the latest inner cylinder and the latest piston assembly have been installed. (Figure 6) Markings "3" or "∴", which may be on the piston rod, indicate that the latest piston assembly has previously been installed.

CAUTION: Make sure that spiral grounding springs are properly installed between rubber bushing on each side of anchor pins when installing cylinders.

NOTE: Refer to information preceding in this section for bleeding Power Trim systems.

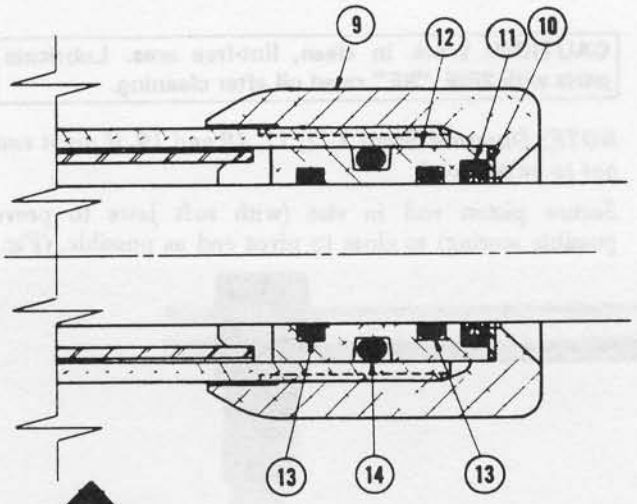
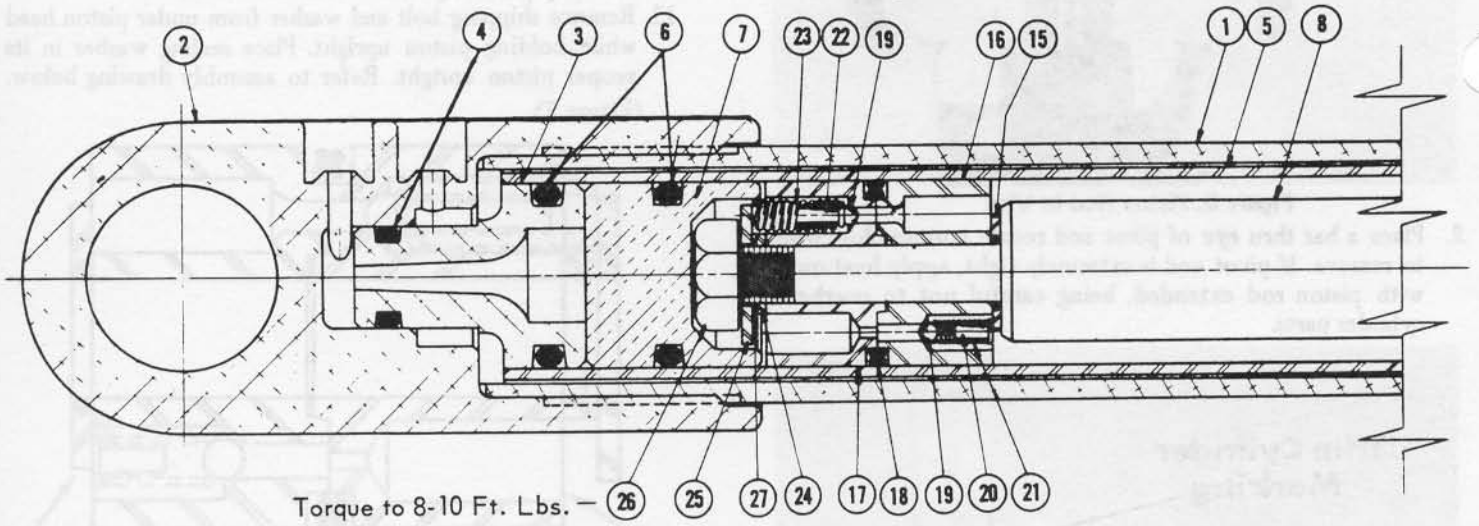


Figure 8. Cylinder Assembly Drawing



1 - Outer Tube Assembly
2 - End Cap, gimbal ring
3 - Inner Tube Guide
4 - "O" Ring
5 - Tube, inner
6 - "O" Ring
7 - Piston, floating
8 - Rod, piston
9 - End Cap, cylinder
10 - Washer, plain
11 - Scraper, rod (Equi-Flex)
12 - Bearing, piston rod
13 - "O" Ring
14 - "O" Ring
15 - Washer, sealing
16 - Shock Piston, return
17 - Shock Piston, impact
18 - Quad Ring (or Seal Ring)
19 - Ball, steel
20 - Rivet, tubular
21 - Spring, by-pass check
22 - Rivet, tubular
23 - Spring, shock relief
24 - Washer, plain
25 - Washer, plain
26 - Nut, 5/16-24 UNF-ESNA
27 - Washer, plain

POWER TRIM CYLINDER
DISASSEMBLY and REASSEMBLY
For MerCruiser II-TR and II-TRS

CAUTION: Work in a clean, lint-free area. Lubricate parts with 20W "SE" rated oil after cleaning.

NOTE: Disregard Steps 1, 2, 16, 17 and 18, if pivot end is not to be replaced.

1. Secure piston rod in vise (with soft jaws to prevent possible scoring) as close to pivot end as possible. (Figure 9)

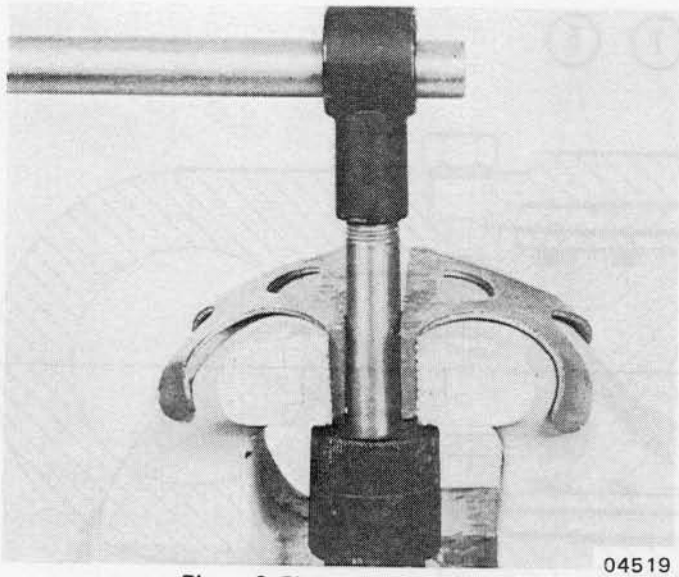


Figure 9. Piston Rod in Vise

2. Place a bar thru eye of pivot and rotate counterclockwise to remove. If pivot end is extremely tight, apply heat only with piston rod extended, being careful not to overheat cylinder parts.

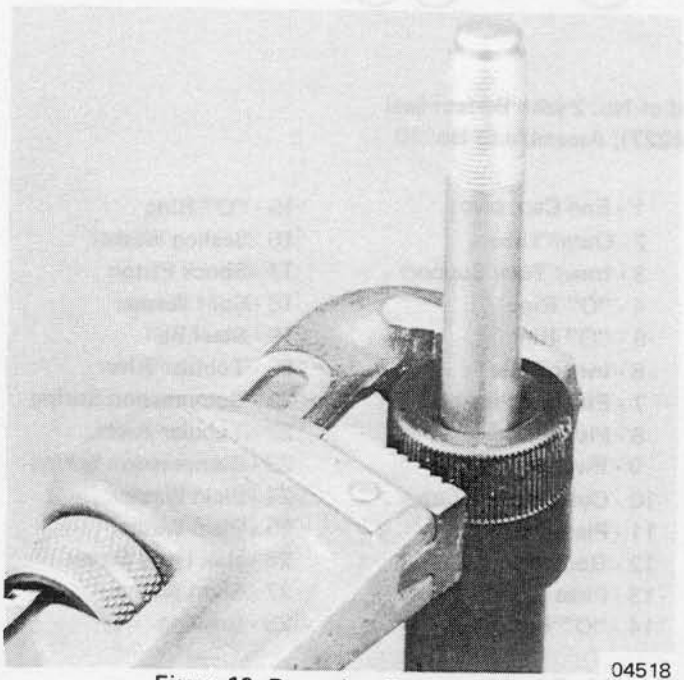


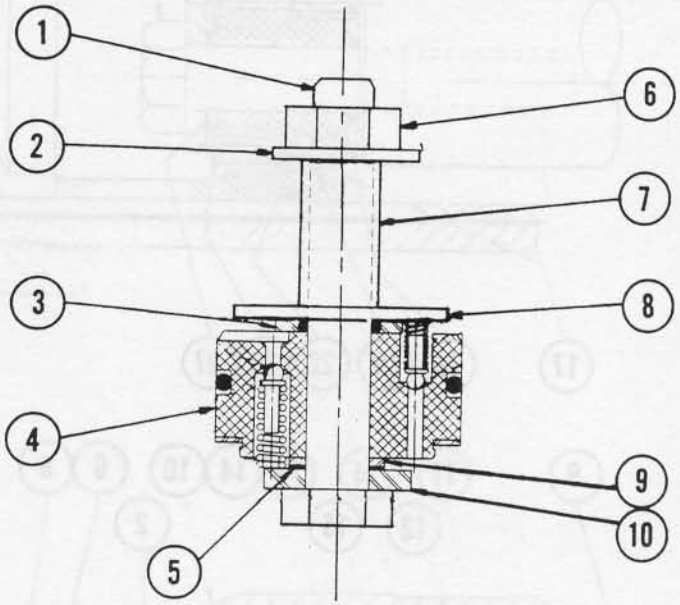
Figure 10. Removing End Cap

3. Rotate cylinder end cap carefully, counterclockwise with a pipe wrench to remove. (Figure 10)
4. Pull piston rod assembly from cylinder (inner cylinder may accompany it).

NOTE: Some trim cylinders have a spacer between piston rod assembly and floating piston in inner cylinder. If spacer is present, it must be reinstalled during reassembly.

5. Remove floating piston and tube support. Use a wire hook to remove tube support, if it remains in outer cylinder.
6. Place piston rod in vise, as in Step 1, and remove screw that holds piston assembly.

NOTE: If piston assembly is to be re-used, take precautions not to lose check balls and springs during removal. Hold in upright position. (Figure 11)



1 - Piston Screw
2 - Washer
3 - Sealing Washer
4 - Piston
5 - Shim Washer
6 - Nut
7 - Spacer
8 - Washer
9 - Washer
10 - Washer

Figure 11. New Piston Assembly

7. Remove piston assembly from piston rod.
8. Remove piston rod bearing. Replace its inner and outer "O" rings.
9. Place end cap (if pivot end is not removed), plain washer, Equi-Flex scraper and piston rod bearing on piston rod.
10. Hold new piston assembly as shown in Figure 10. Remove nut ("6" in Figure 11) from end of piston screw. Carefully lift off washer ("2"), spacer ("7") and washer ("8") and discard. DO NOT remove sealing washer.

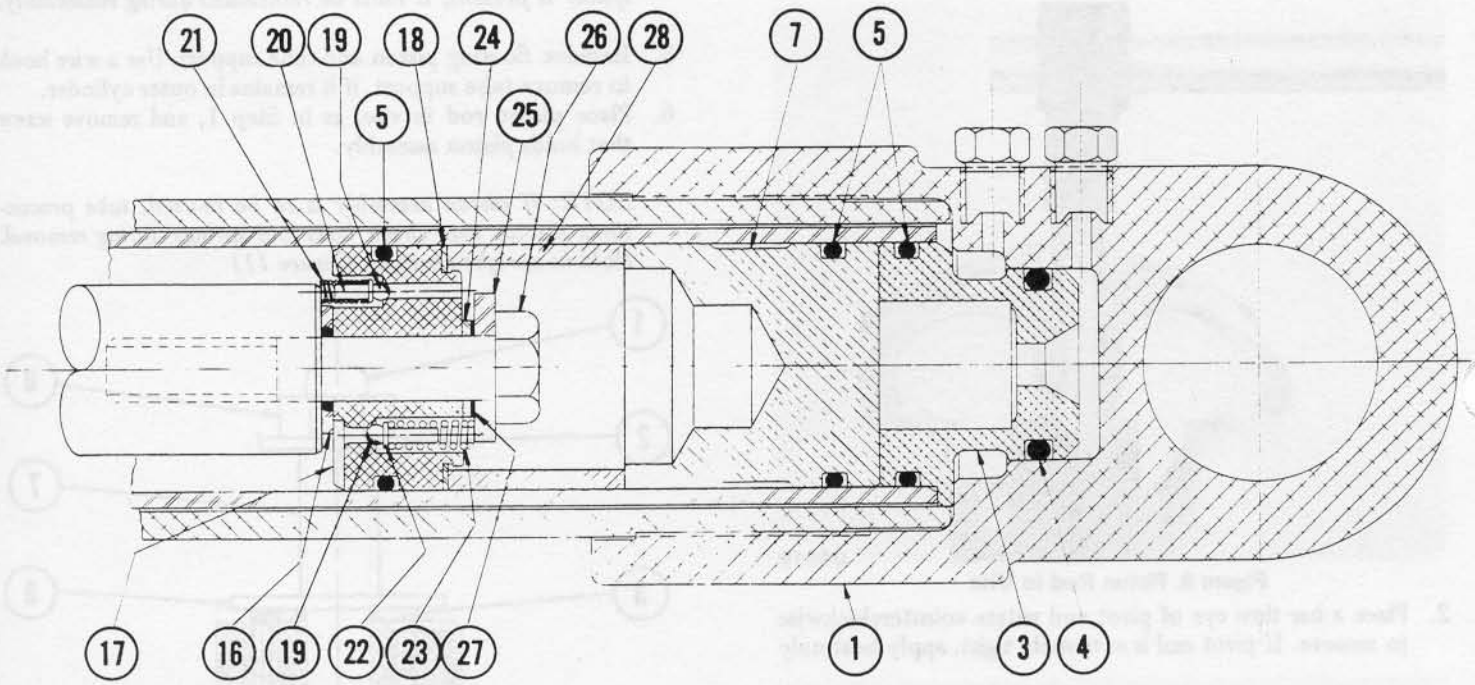
11. Hold piston in upright position and apply Loctite "A" (C-92-32609) to threads of piston screw. Turn rod onto piston screw far enough to secure check balls and springs.
12. Secure piston rod in vise (as in Step 1) and torque piston screw 15 to 20 ft. lbs. (2.1 to 2.8mkg).
13. Place new "O" rings on floating piston and tube support. Place them into inner cylinder and position assembly in outer cylinder. Refer to assembly drawing, Figure 12.

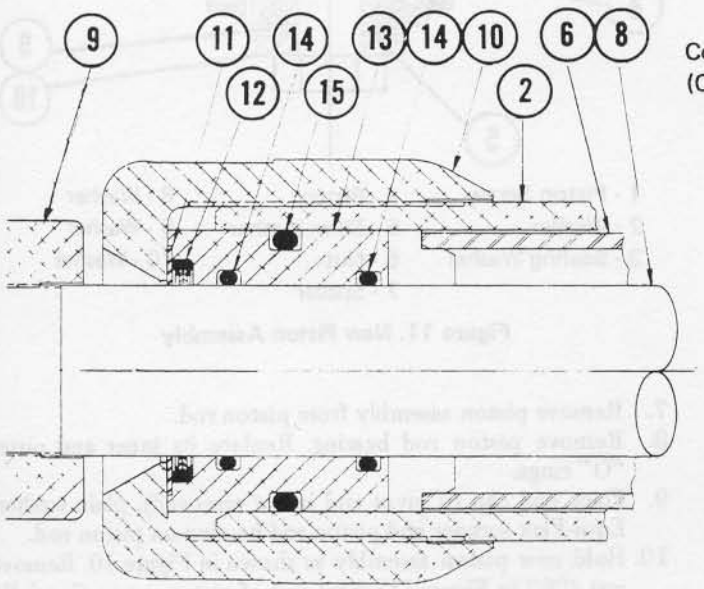
NOTE: If a spacer was removed from between piston rod assembly and floating piston, install spacer at this time.

14. Insert piston rod and piston into inner cylinder while fitting piston rod bearing into outer cylinder.
15. Coat threads of outer cylinder with Perfect Seal (C-92-34227) and install end cap unto cylinder. Torque to 35 to 45 ft. lbs. (4.8 to 6.2mkg).
16. Secure piston rod in vise as close to pivot end threads as possible. (Figure 9)
17. Clean threads on piston rod and apply Loctite (C-92-36088).
18. Replace pivot end and torque to 30 to 40 ft. lbs. (4.2 to 5.5mkg).
19. Paint over scratches to protect exposed metal.

CAUTION: Make sure that spiral grounding springs are properly installed between rubber bushing on each side of anchor pins when installing cylinders.

NOTE: Refer to information preceding in this section for bleeding Power Trim systems.





Coat end of No. 2 with Perfect Seal (C-92-34227); Assemble to No. 10

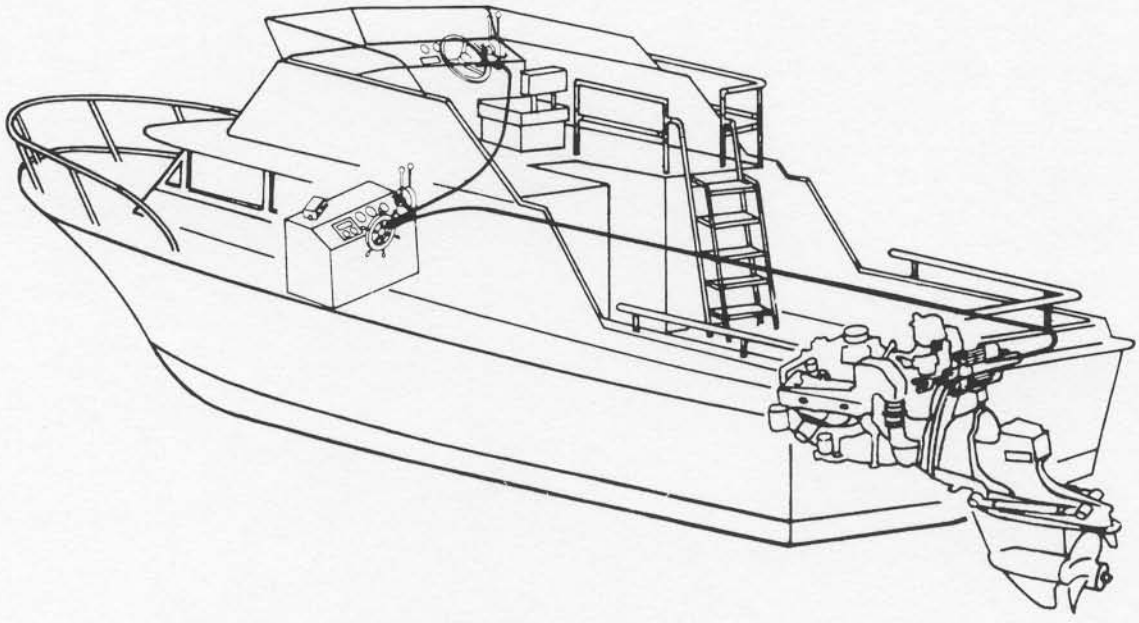
1 - End Cap, pivot
2 - Outer Tube
3 - Inner Tube Support
4 - "O" Ring
5 - "O" Ring
6 - Inner Tube
7 - Floating Piston
8 - Piston Rod
9 - Pivot, end
10 - Cylinder End Cap
11 - Plain Washer
12 - Rod Scraper
13 - Piston Rod Bearing
14 - "O" Ring
15 - "O" Ring
16 - Sealing Washer
17 - Shock Piston
18 - Split Washer
19 - Steel Ball
20 - Tubular Rivet
21 - Compression Spring
22 - Tubular Rivet
23 - Compression Spring
24 - Plain Washer
25 - Plain Washer
26 - Hex Head Screw
27 - Shim Washer
28 - Bushing

Figure 12. Cylinder Assembly Drawing

SECTION 7 - ACCESSORIES

mercruiser

PART B - STEERING SYSTEMS



MERCURY MARINE

A BRUNSWICK COMPANY

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STEERING SYSTEMS

Steering system information is divided into 3 sections:

1. **Rack-and-Pinion type with 90°, 20° and Tilt Wheel Mount**
2. **Directional Indicator**
3. **Rotary Steering with 90°, 20° and Tilt Wheel Mount**

NOTE: The following procedures are for complete disassembly, cleaning and inspection and reassembly. Disassembly may be stopped at any point desired and reassembly begun at that point. It is, however, recommended that complete disassembly, cleaning and inspection and reassembly be performed as a normal course of repair.

DIRECTIONAL INDICATOR TYPE

DISASSEMBLY

NOTE: Refer to Figure 1 for parts identification.

1. Remove button from center of steering wheel.
2. Use a 7/16" socket to remove bolt, lockwasher and washer from inside hub. (Figure 1)
3. Remove hub from inside center of steering wheel.
4. Remove bushing from inside of hub.
5. Hold steering wheel from turning while removing elastic stop nut and washer from bottom end of steering wheel center bolt.
6. Lift steering wheel and center bolt off steering shaft.
7. Remove directional indicator nylon pinion shaft from inside of steering wheel.
8. Remove nut, bolt and spacer from gear rack assembly to steering mount.
9. Remove gear rack assembly from steering mount.
10. Remove rubber cap from end of rack and move transom end of cable to bottom-out inner core cable. Remove cotter pin from locking cap and remove locking cap (if so equipped). Remove "jam" nut and retainer nut.
11. Loosen steering cable to gear rack "jam" nut and turn gear rack off steering cable.
13. Remove pinion gear bushings from gear rack.
14. Remove upper and lower steering shaft bushings from steering mount.
15. Remove 6 bolts and nuts which hold gear rack housings together.
16. Separate gear rack housings and remove tubes from housings. Slide tubes off rack gear.

CLEANING and INSPECTION

1. Clean all parts with solvent and dry with compressed air.
2. Inspect steering shaft, pinion gear, rack gear and rack gear tubes for wear and/or galled surfaces.
3. Inspect all bushings for wear and/or cracks.
4. Replace parts as necessary.

ASSEMBLY

SAFETY WARNING: Elastic-type locknuts may be safely used 2 or 3 times ONLY. If the locking ability of the elastic locknut is questionable, replace with a new elastic-type locknut as specified in the Parts Manual. DO NOT USE worn-out locknuts or non-locking nuts.

1. Apply a liberal coat of Universal Joint Lubricant to inside of rack tubes and rack gear.
2. Place end of rack gear (with smaller diameter hole) into rack tube which has open end.
3. Place rack tube, which has threaded hole for steering cable, over other end of rack gear.
4. Place rack gear with tubes into center housing, with groove in bottom of rack gear over stop in center housing. Be sure that rack tubes are properly seated into grooves in center housing.
5. Place other half of center housing over rack tubes and secure with 6 bolts and nuts. TORQUE nuts to 70 in. lbs. (81kg-cm).
6. Lubricate outer surfaces of pinion gear bushings with Universal Joint Lubricant and install bushings into pinion openings in gear rack assembly.
7. Install pinion gear into gear rack assembly with steering shaft spline (smaller diameter spline) toward steering mount.
8. Thread gear rack assembly onto steering cable.

CAUTION: DO NOT thread steering cable into gear rack. Instead, thread gear rack all the way onto steering cable so that cable housing will not wind up and cause hard steering.

9. Push transom end of steering cable inward to bottom-out inner core cable.
10. Clean grease from inner core cable threaded area which is exposed beyond rack gear.
11. Thread cable retainer nut onto inner core cable and TORQUE to 90 in. lbs. (104kg-cm). Install second nut and tighten securely; DO NOT EXCEED 90 in. lbs. Install locking cap over cable core nuts and install cotter pin (if so equipped). Install rubber cap to end of tube.
12. Move transom end of steering cable in-and-out several times to be sure that no bind exists in steering cable of rack assembly.
13. If steering cable is attached to drive unit, place drive unit in a straight-ahead position. Install large ID washer over pinion gear steering mount side.
14. Lubricate steering shaft bushings with Universal Joint Lubricant and install bushings into steering mount.
15. Place gear rack assembly in position behind steering mount and secure it with ⅜" (9.5mm) diameter bolt, spacer and nut. DO NOT torque nut at this time.
16. Place steering shaft into steering mount and index it so that one flat (tapered portion flat side) is horizontal. This will reference steering shaft and steering wheel spoke position correctly when boat is traveling straight-ahead.
17. Torque ⅜" diameter bolt (from Step 15) to 25 ft. lbs. (3.46mkg).
18. Lubricate directional indicator pinion gear with Universal Joint Lubricant and install it into steering wheel with letter "F" toward driver's position.
19. Place steering wheel over steering shaft with spokes of wheel horizontal. Install center bolt thru steering wheel, shaft and pinion gear. Secure center bolt with washer and elastic stop nut.
20. Torque center bolt retainer nut to 80 in. lbs. (92kg-cm). Torque steering cable to gear rack "jam" nut to 30 ft. lbs. (4.15mkg).
21. Lubricate indicator hub bushing with Universal Joint Lubricant and install it into center of steering wheel. Place hub into center of steering wheel and turn it to engage gear teeth on hub with teeth on pinion gear.

22. Secure hub to center bolt with bolt, lockwasher and washer.
23. Install indicator button in center of steering wheel with "Ride-Guide" horizontal and arrow (narrow end) to top.
24. Rotate steering wheel thru entire steering range to be sure that no bind exists in steering cable, rack gear or steering mount.

WARNING: Check that boat will turn right when steering wheel is turned right, and that boat will turn to left when steering wheel is turned left.

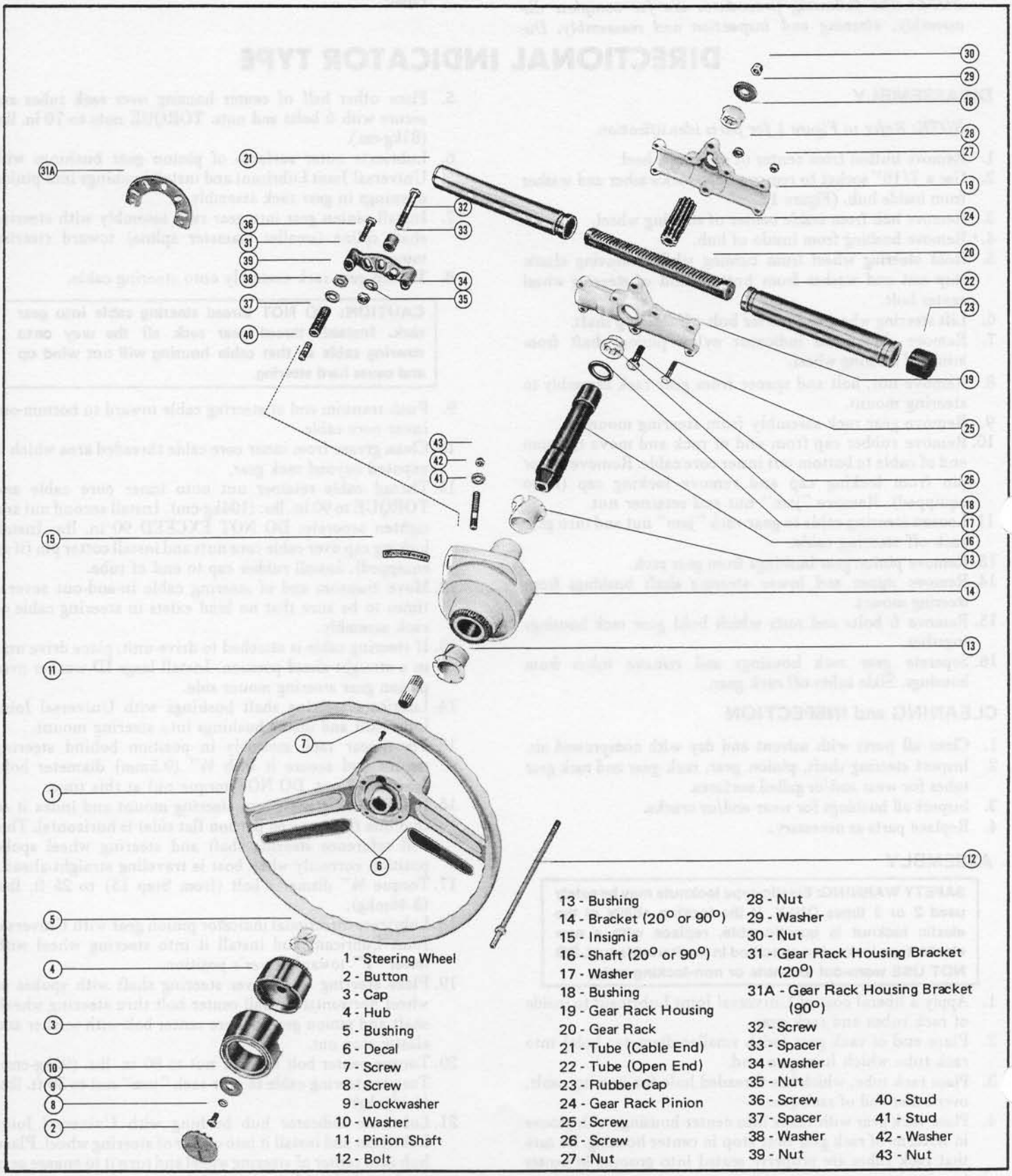


Figure 1. Directional Indicator Type Steering

RACK and PINION TYPE - 20° - 90° and TILTING MOUNT

DISASSEMBLY

NOTE: Refer to Figure 2 or 3 for parts identification.

1. Remove button from center of steering wheel.
2. Remove center bolt retainer nut and large OD washer and lift off steering wheel.
3. Remove two 3/8" bolts and lockwashers which secure gear rack to steering mount.
4. Remove pinion gear, pinion gear bushings and large ID washer.
5. Push transom end of steering cable inward to bottom out inner core cable.
6. Remove rubber cap from end of rack and move transom end of cable to bottom-out inner core cable. Remove cotter pin from locking cap and remove locking cap (if so equipped). Remove "jam" nut and retainer nut.
7. Loosen steering cable to gear rack "jam" nut and turn gear rack off steering cable.
8. Remove 6 bolts and nuts which secure gear rack housings to gear rack tubes. Separate housings and remove gear rack tubes from housings.
9. Slide gear rack tubes off rack gear.

CLEANING and INSPECTION

1. Wash all parts in solvent and dry with compressed air.
2. Inspect all bushings for wear, cracks and broken surfaces. Replace as necessary.
3. Inspect rack gear and pinion gear for wear on gear teeth.
4. Inspect rack tubes, rack gear and steering shaft (bushing surfaces) for wear and/or galling of surfaces.

ASSEMBLY

SAFETY WARNING: Elastic-type locknuts may be safely used 2 or 3 times ONLY. If the locking ability of the elastic locknut is questionable, replace with a new elastic-type locknut as specified in the Parts Manual. DO NOT USE worn-out locknuts or non-locking nuts.

1. Apply a liberal coat of Universal Joint Lubricant to inside surfaces of rack tubes and rack gear.
2. Insert rack gear (with smaller hole end) into rack tube which has the open end (rubber cap end).
3. Place steering cable end (with tapped hole in end) over other end of rack gear.
4. Place rack gear (with rack tubes in place) into center housing. Be sure that groove in rack gear is over stop in bottom center of housing, and that grooves in rack tubes are seated in ridges on housing.
5. Place other center housing over rack tubes and secure with 6 bolts and nuts. TORQUE nuts to 70 in. lbs. (81kg-cm).
6. Thread gear rack housing onto steering cable all-the-way.

CAUTION: DO NOT thread steering cable into gear rack. Instead, thread gear rack onto steering cable so that cable housing will not wind up and cause hard steering.

7. Push on transom end of steering cable to bottom-out inner core cable.
8. Clean grease from inner core cable which is exposed beyond rack gear.
9. Thread cable retainer nut onto inner core cable and TORQUE to 90 in. lbs. (104kg-cm). Install second nut and tighten securely; DO NOT EXCEED 90 in. lbs. Install locking cap over cable core nuts and install cotter pin (if so equipped). Install rubber cap to end of tube.
10. Move transom end of steering cable in-and-out several times to be sure that no bind exists in steering cable or gear rack assembly.
11. Move transom end of steering cable in-and-out, as necessary, to center rack gear in pinion gear opening. Only one tooth on rack gear has a center mark on it.
12. Lubricate pinion gear bushings with Universal Joint Lubricant and install bushings into pinion gear openings of gear rack assembly.
13. Position gear rack with pinion gear opening below rack gear. Install pinion gear into gear rack assembly with steering shaft spline (smaller spline end) toward steering mount.
14. Place washer with large ID over steering shaft splines of pinion gear.
15. Place gear rack assembly flush against steering mount flange and install gear rack retainer bolts and washers. DO NOT tighten retainer bolts at this time.
16. Lubricate steering shaft bushings with Universal Joint Lubricant and install bushings into steering mount.
17. Install steering shaft into steering mount with one flat of squared end horizontal. Hold pinion gear in position while engaging steering shaft with pinion gear splines.
18. TORQUE gear rack retainer bolts (from Step 15) to 25 ft. lbs. (3.46mkg).
19. View steering wheel from back side. Steering post recess (square opening) has one flat side above spoke in steering wheel.
20. Install steering wheel to steering shaft with flat areas aligned (from Steps 17 and 19).
21. Install center bolt thru steering wheel, shaft and pinion gear. Secure center bolt with large OD washer and elastic stop nut. TORQUE nut to 80 in. lbs. (92kg-cm).
22. Rotate steering wheel thru entire steering range several times to be sure that no bind exists in steering mount, rack gear and/or cable.
23. Install button in center of steering wheel.

WARNING: Check that boat will turn to right when steering wheel is turned to right, and that boat will turn left when steering wheel is turned left.

Parts Identification for Figure 2

1 - Steering Wheel (Not Necessarily as Shown)
2 - Button
3 - Bolt
4 - Bushing
5 - Bracket (20°)
5A - Bracket (90°)
6 - Decal
7 - Shaft
8 - Washer
9 - Bushing
10 - Gear Rack Housing
11 - Gear Rack
12 - Tube (Cable End)
13 - Tube (Open End)
14 - Rubber Cap
15 - Gear Rack Pinion
16 - Screw
17 - Screw
18 - Nut
19 - Nut
20 - Washer
21 - Nut
22 - Bracket (20°)
22A - Bracket (90°)
23 - Screw
24 - Spacer
25 - Washer
26 - Nut
27 - Screw
28 - Spacer
29 - Washer
30 - Nut
31 - Stud
32 - Stud
33 - Washer
34 - Nut

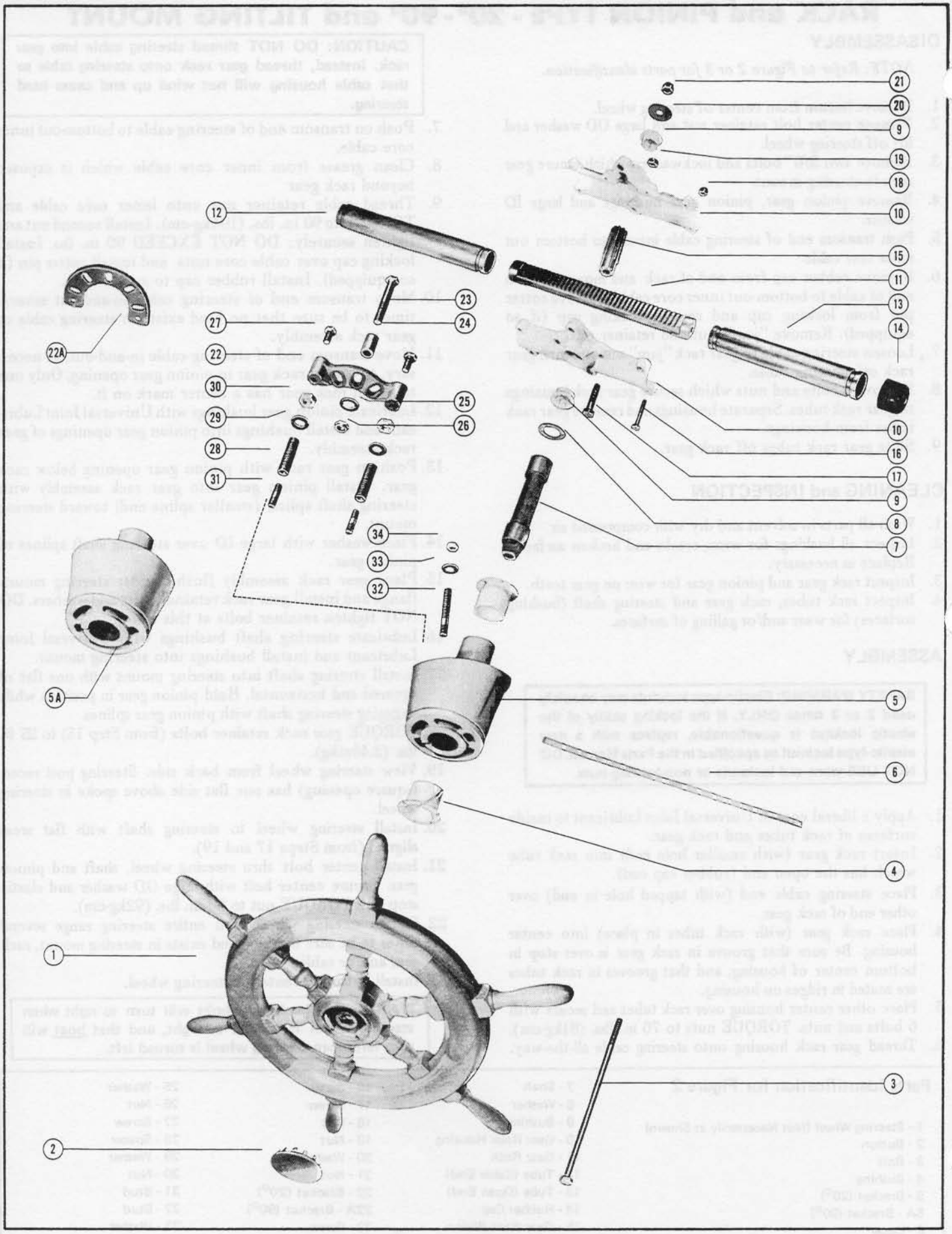
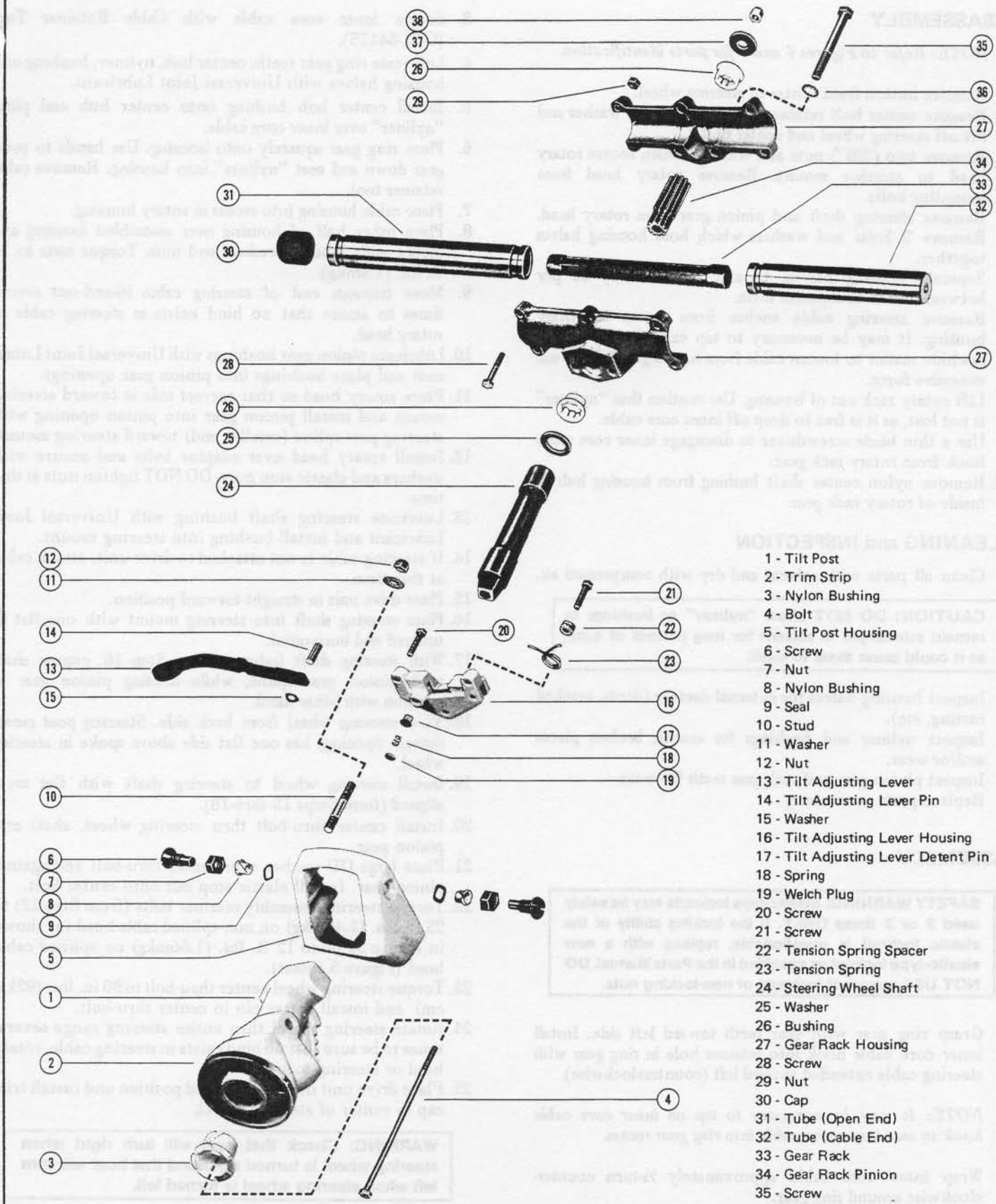


Figure 2. 20° and 90° Mount Type Steering



1 - Tilt Post
2 - Trim Strip
3 - Nylon Bushing
4 - Bolt
5 - Tilt Post Housing
6 - Screw
7 - Nut
8 - Nylon Bushing
9 - Seal
10 - Stud
11 - Washer
12 - Nut
13 - Tilt Adjusting Lever
14 - Tilt Adjusting Lever Pin
15 - Washer
16 - Tilt Adjusting Lever Housing
17 - Tilt Adjusting Lever Detent Pin
18 - Spring
19 - Welch Plug
20 - Screw
21 - Screw
22 - Tension Spring Spacer
23 - Tension Spring
24 - Steering Wheel Shaft
25 - Washer
26 - Bushing
27 - Gear Rack Housing
28 - Screw
29 - Nut
30 - Cap
31 - Tube (Open End)
32 - Tube (Cable End)
33 - Gear Rack
34 - Gear Rack Pinion
35 - Screw
36 - Lockwasher
37 - Washer
38 - Nut

Figure 3. Tilting Mount Type Steering

ROTARY STEERING

DISASSEMBLY

NOTE: Refer to Figures 4 and 5 for parts identification.

1. Remove button from center of steering wheel.
2. Remove center bolt retainer nut and large OD washer and lift off steering wheel and center bolt.
3. Remove two (3/8") nuts and washers which secure rotary head to steering mount. Remove rotary head from mounting bolts.
4. Remove steering shaft and pinion gear from rotary head.
5. Remove 2 bolts and washers which hold housing halves together.
6. Separate housing halves. It may be necessary to pry between halves to separate them.
7. Remove steering cable anchor from recess in rotary housing. It may be necessary to tap cable lightly with a rawhide mallet to loosen cable from housing. DO NOT use excessive force.
8. Lift rotary rack out of housing. Use caution that "nyliner" is not lost, as it is free to drop off inner core cable.
9. Use a thin blade screwdriver to disengage inner core cable hook from rotary rack gear.
10. Remove nylon center shaft bushing from housing hub or inside of rotary rack gear.

CLEANING and INSPECTION

1. Clean all parts with solvent and dry with compressed air.

CAUTION: DO NOT allow "nyliner" or bushings to remain submerged in solvent for long periods of time, as it could cause them to swell.

2. Inspect housing halves for external damage (dents, cracked casting, etc).
3. Inspect nyliner and bushings for cracks, broken pieces and/or wear.
4. Inspect pinion gear and rack gear teeth for wear.
5. Replace parts as necessary.

ASSEMBLY

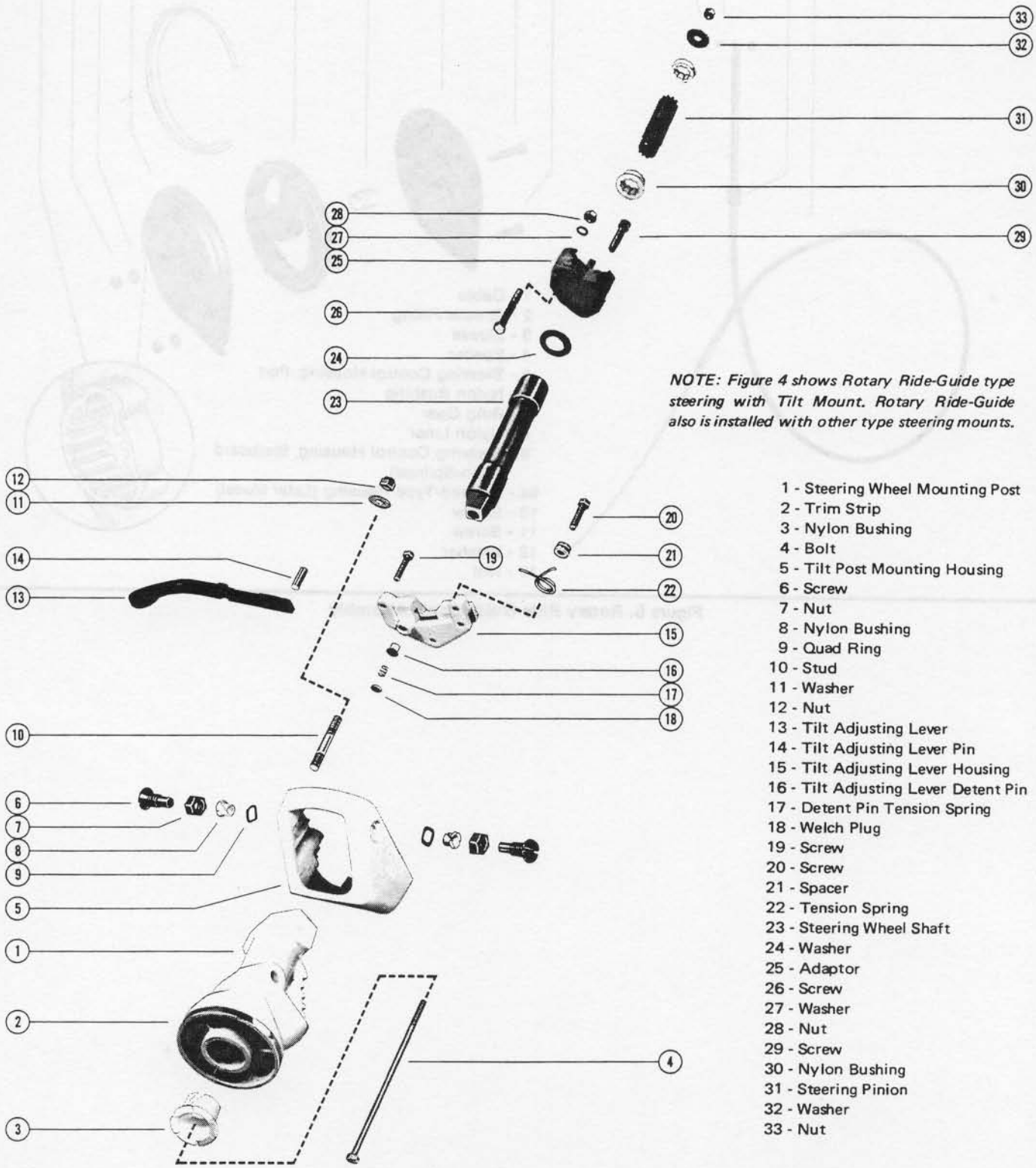
SAFETY WARNING: Elastic-type locknuts may be safely used 2 or 3 times ONLY. If the locking ability of the elastic locknut is questionable, replace with a new elastic-type locknut as specified in the Parts Manual. DO NOT USE worn-out locknuts or non-locking nuts.

1. Grasp ring gear with gear teeth toward left side. Install inner core cable hook into retainer hole in ring gear with steering cable extended toward left (counterclockwise).

   NOTE: It may be necessary to tap on inner core cable hook to seat inner core cable into ring gear recess.

2. Wrap inner core cable approximately ½-turn counterclockwise around ring gear.
3. Secure inner core cable with Cable Retainer Tool (C-91-54175).
4. Lubricate ring gear teeth, center hub, nyliner, bushing and housing halves with Universal Joint Lubricant.
5. Install center hub bushing onto center hub and place "nyliner" over inner core cable.
6. Place ring gear squarely onto housing. Use hands to press gear down and seat "nyliner" into housing. Remove cable retainer tool.
7. Place cable housing into recess in rotary housing.
8. Place other half of housing over assembled housing and secure with 2 bolts, washers and nuts. Torque nuts to 10 ft. lbs. (1.4mkg).
9. Move transom end of steering cable in-and-out several times to assure that no bind exists in steering cable or rotary head.
10. Lubricate pinion gear bushings with Universal Joint Lubricant and place bushings into pinion gear openings.
11. Place rotary head so that correct side is toward steering mount and install pinion gear into pinion opening with steering post spline (smaller end) toward steering mount.
12. Install rotary head over adaptor bolts and secure with washers and elastic stop nuts. DO NOT tighten nuts at this time.
13. Lubricate steering shaft bushing with Universal Joint Lubricant and install bushing into steering mount.
14. If steering cable is not attached to drive unit, attach cable at this time.
15. Place drive unit in straight-forward position.
16. Place steering shaft into steering mount with one flat c squared end horizontal.
17. With steering shaft indexed as in Step 16, engage shaft with pinion gear spline, while holding pinion gear in position with other hand.
18. View steering wheel from back side. Steering post recess (square opening) has one flat side above spoke in steering wheel.
19. Install steering wheel to steering shaft with flat areas aligned (from Steps 15-thru-18).
20. Install center thru-bolt thru steering wheel, shaft and pinion gear.
21. Place large OD washer over center thru-bolt and against pinion gear. Install elastic stop nut onto center bolt.
22. Torque steering assembly retainer bolts (from Step 12) to 25 ft. lbs. (3.46mkg) on non-splined cable head (as shown in Figure 5) or to 12 ft. lbs. (1.66mkg) on splined cable head (Figure 5 insert).
23. Torque steering wheel center thru-bolt to 80 in. lbs. (92kg-cm) and install cotter pin in center thru-bolt.
24. Rotate steering wheel thru entire steering range several times to be sure that no bind exists in steering cable, rotary head or steering mount.
25. Place drive unit in straight-ahead position and install trim cap in center of steering wheel.

WARNING: Check that boat will turn right when steering wheel is turned right and that boat will turn left when steering wheel is turned left.



NOTE: Figure 4 shows Rotary Ride-Guide type steering with Tilt Mount. Rotary Ride-Guide also is installed with other type steering mounts.

1 - Steering Wheel Mounting Post
2 - Trim Strip
3 - Nylon Bushing
4 - Bolt
5 - Tilt Post Mounting Housing
6 - Screw
7 - Nut
8 - Nylon Bushing
9 - Quad Ring
10 - Stud
11 - Washer
12 - Nut
13 - Tilt Adjusting Lever
14 - Tilt Adjusting Lever Pin
15 - Tilt Adjusting Lever Housing
16 - Tilt Adjusting Lever Detent Pin
17 - Detent Pin Tension Spring
18 - Welch Plug
19 - Screw
20 - Screw
21 - Spacer
22 - Tension Spring
23 - Steering Wheel Shaft
24 - Washer
25 - Adaptor
26 - Screw
27 - Washer
28 - Nut
29 - Screw
30 - Nylon Bushing
31 - Steering Pinion
32 - Washer
33 - Nut

Figure 4. Rotary Ride-Guide Type Steering with Tilt Mount Assembly

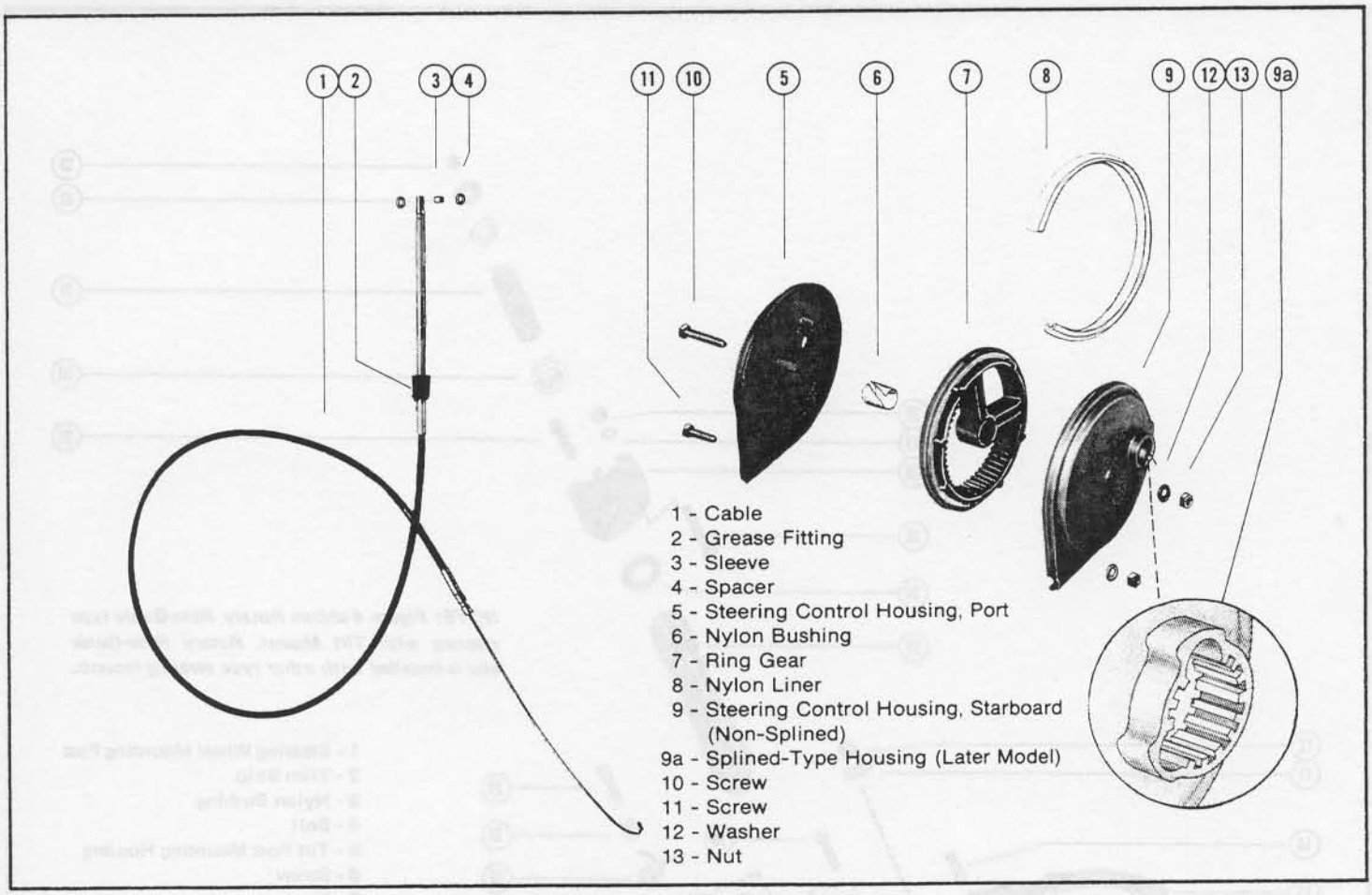


Figure 5. Rotary Ride-Guide Cable Assembly

RACK and PINION TYPE (with Square Rack Housing)

DISASSEMBLY

NOTE: Refer to Figure 6 for parts identification.

1. Remove button from center of steering wheel.
2. Remove cotter pin, locknut and large OD washer from center thru-bolt and remove steering wheel and center thru-bolt.
3. Remove two 3½" (89mm) bolts, locknuts and washers which secure rack to steering mount.
4. Remove pinion gear, pinion gear bushings and large ID washer.
5. Remove rack housing cover and push transom end of steering cable inward to bottom-out rack against stop bracket.
6. Remove cotter pin from inner core cable and locking cap and remove locking cap and 2 cable retaining nuts.
7. Loosen cable jam nut and turn rack off cable. DO NOT turn cable off of rack, as twisting cable may cause damage.
8. Remove two ¾" (19mm) stop bracket retaining bolts, four 1⅛" (28.6mm) pinion housing retaining bolts and two 2" (50.8mm) cable mount retaining bolts with related washers and locknuts.
9. Remove cable mount, rack and rack bushing and guide from rack housing.

CLEANING and INSPECTION

1. Wash all parts in solvent and dry with compressed air.
2. Inspect bushings for wear, cracks or broken surfaces. Replace as necessary.
3. Inspect rack gear and pinion gear for wear on gear teeth.
4. Inspect rack housing and steering shaft bushing surfaces for wear and/or galling of surfaces.

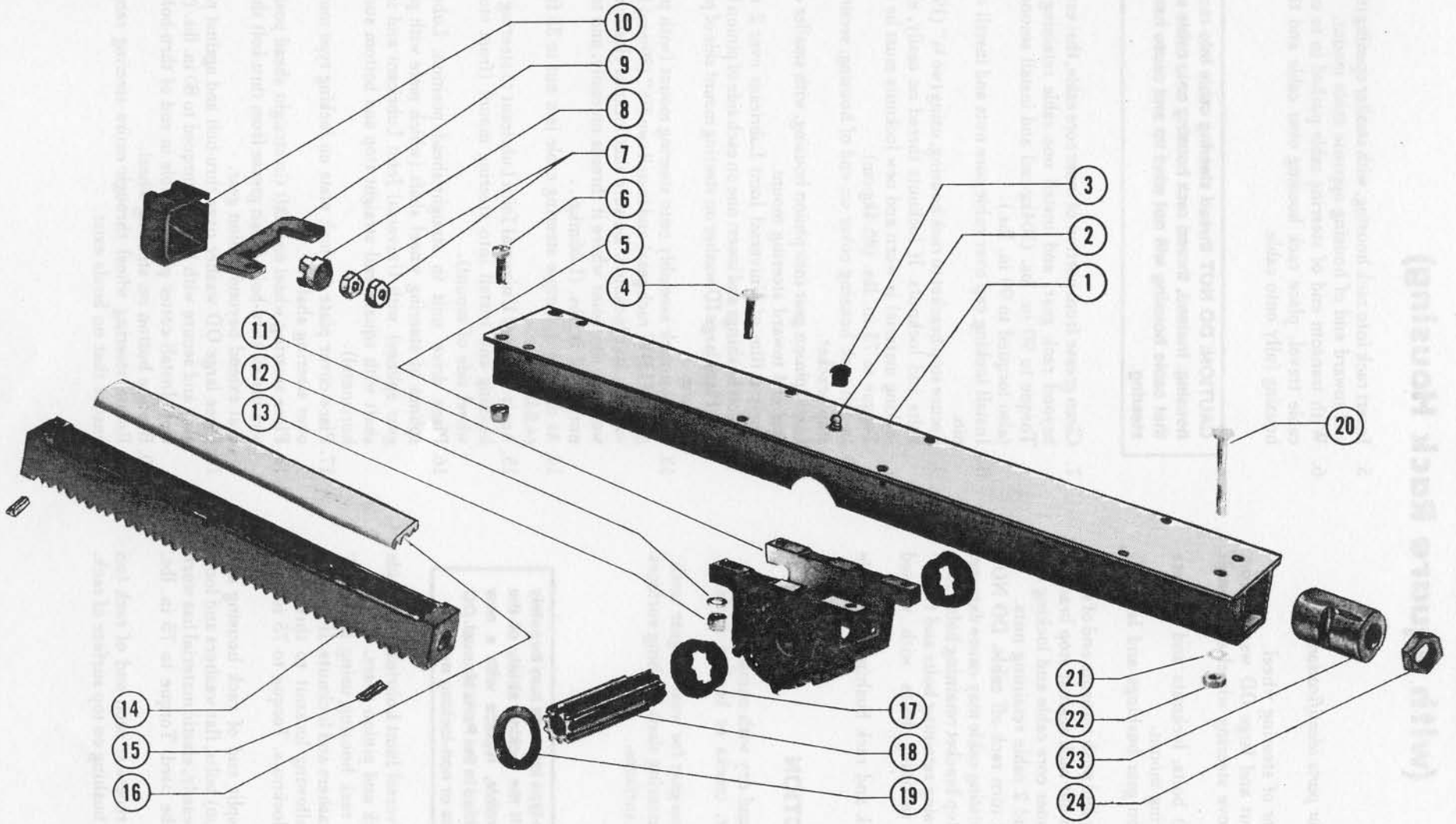
ASSEMBLY

SAFETY WARNING: Elastic-type locknuts may be safely used 2 or 3 times ONLY. If the locking ability of the elastic locknut is questionable, replace with a new elastic-type locknut as specified in the Parts Manual. DO NOT USE worn-out locknuts or non-locking nuts.

1. Apply a liberal coat of Universal Joint Lubricant to inside of rack housing and to rack and pinion gears.
2. Attach pinion housing to rack housing, using four 1⅛" (28.6mm) bolts with flat washers and locknuts. If locknut elastic lining has worn (allowing locknut to thread on easily), replace with new locknuts. Torque to 75 in. lbs. (86.4kg-cm).
3. Install cable mount into split end of rack housing and secure with two 2" (50.8mm) bolts, flat washers and locknuts. If locknuts thread on easily, elastic material has worn and new locknuts MUST be used. Torque to 75 in. lbs. (86.4kg-cm).
4. Place one rack guide into recess at each end of rack (on gear side) and position flat bushing on top surface of rack.
5. Insert rack into rack housing, with smaller opening in rack end toward end of housing opposite cable mount.
6. With transom end of steering cable pushed in to end of cable travel, place rack housing over cable and thread housing fully onto cable.

CAUTION: DO NOT thread steering cable into rack housing. Instead, thread rack housing onto cable so that cable housing will not wind up and cause hard steering.

7. Clean grease from portion of inner core cable, that extends beyond rack gear, and install one cable retaining nut. Torque to 90 in. lbs. (104kg-cm) and install second nut (also torqued to 90 in. lbs.).
8. Install locking cap over cable core nuts and install cotter pin.
9. Secure stop bracket to rack housing, using two ¾" (19mm) bolts and locknuts. If locknuts thread on easily, elastic locking material is worn and new locknuts must be used. Torque to 75 in. lbs. (86.4kg-cm).
10. Install rack housing cover on end of housing, secured to stop bracket.
11. Insert pinion gear into pinion housing, with smaller diameter end toward steering mount.
12. Apply a film of Universal Joint Lubricant over 2 nylon pinion bushings and insert one on each side of pinion housing. Place large ID washer on steering mount side of pinion housing.
13. Position rack assembly onto steering mount (with pinion gear BELOW rack gear) and install two 3½" (89mm) bolts, washers and locknuts. Be sure that locknut elastic is not worn to the point where it threads on easily, and torque nuts to 12 ft. lbs. (1.66mkg).
14. At this point, torque steering cable jam nut to 35 ft. lbs. (4.84mkg).
15. Apply a film of Universal Joint Lubricant to steering shaft bushing and install into steering mount (from steering wheel side of mount).
16. Place drive unit in straight-ahead position. Lubricate splines of steering wheel shaft (which mate with pinion gear splines) with Universal Joint Lubricant and install shaft with square end straight (top and bottom surfaces horizontal).
17. Place cover plate (or lock plate on locking type mounts) over steering shaft.
18. Place steering wheel on shaft (in straight ahead position) and install thru-bolt. Clean grease from thru-bolt threads that extend beyond pinion gear.
19. Place large OD washer over thru-bolt and against pinion gear and secure with locknut torqued to 80 in. lbs. (92kg-cm). Install cotter pin thru hole in end of thru-bolt.
20. Replace button on steering wheel.
21. Rotate steering wheel through entire steering range to ensure that no binds exist.



1 - Rack Housing
2 - Grease Fitting
3 - Lubricap
4 - Bolt, Pinion Housing to Rack Housing (1-1/8") (4)
5 - Nut, Stop Bracket Bolt (2)
6 - Bolt, Stop Bracket (3/4") (2)
7 - Nut, Steering Cable to Rack (2)
8 - Locking Cap
9 - Stop Bracket
10 - Rack Housing Cover
11 - Pinion Housing (or Rack Mount Housing)
12 - Washer, Pinion Housing to Rack Housing Bolt (4)
13 - Nut, Pinion Housing to Rack Housing Bolt (4)
14 - Rack
15 - Rack Guide (2)
16 - Rack Bushing
17 - Pinion (Nylon) Bushing (2)
18 - Pinion
19 - Washer, Pinion Securing
20 - Bolt, Cable Mount to Rack Housing (2") (2)
21 - Washer, Cable Mount to Rack Housing (2)
22 - Nut, Cable Mount to Rack Housing (2)
23 - Cable Mount
24 - Jam Nut, Cable to Cable Mount

Quantity at right when more than one is used.

Figure 6. Rack and Pinion S[illegible]ring (with Square Rack)

MERCRUISER "PRE-ADJUSTED" POWER STEERING UNIT

ADJUSTING STEERING

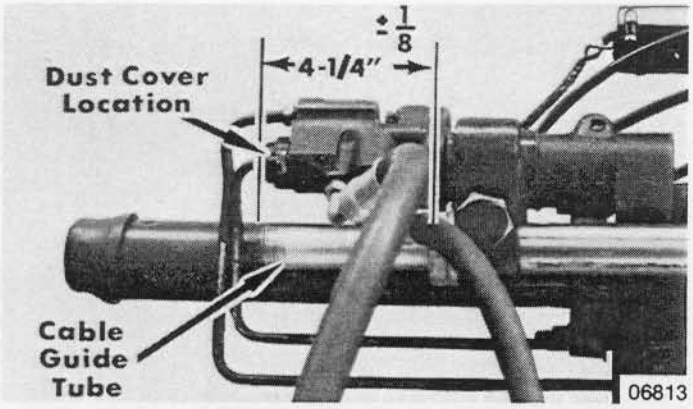


Figure 1. Ride-Guide Tube Dimension - 110-thru-470 and MerCruiser III

Ride-Guide tube is pre-set at factory so that further adjusting of cable is not necessary. Should large nut and cable guide tube become loose, or pump lugging occurs when cable is fully extended from Ride-Guide tube (with link rod attached), then dimension (shown in Figure 1 or 2) must be checked and corrected if necessary.

CAUTION: If above adjustments are used on other than B.I.A. approved cables, damage to drive and/or steering system may occur.

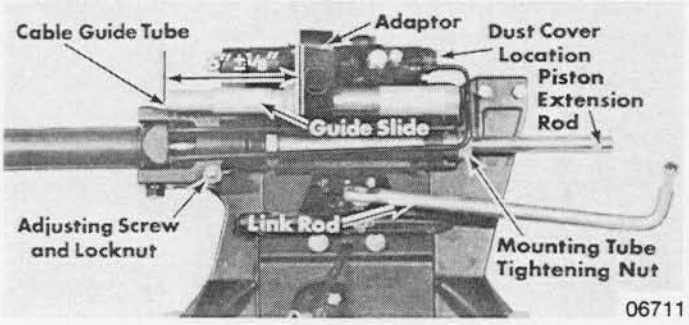


Figure 2. Ride-Guide Tube Dimension - V-8 Models

CONTROL VALVE BALANCING

1. Detach steering input cable from valve and adaptor. Remove adaptor from end of cylinder piston extension rod and remove dust cover. (Figure 1 or 2)
2. Check system hoses and fill pump reservoir to proper level.

IMPORTANT: Do not operate engine without cooling water flowing through water pickup pump(s).

3. Start engine, then -
   a. If piston extension rod remains retracted, turn adjusting nut (Figure 3) clockwise until piston rod begins to extend, then turn nut counterclockwise until rod just begins to retract. Now turn nut clockwise to exactly ½ the rotation needed to change direction of piston rod movement.
   b. If piston rod extends, turn adjusting nut (Figure 3) counterclockwise until piston rod begins to retract, then turn nut clockwise until rod just begins to extend. Now turn nut counterclockwise to exactly ½ the rotation needed to change direction of the piston rod movement.

NOTE: DO NOT move adjusting nut more than necessary, so nut friction-locking quality is retained.

4. Turn off engine. Reinstall input cable and adaptor.
5. Restart engine. If cable end adaptor does not move in either direction, valve adjustment is correct. If not, re-balance valve, as in Steps 1-thru-4.
6. Stop engine after valve is adjusted. Place Universal Joint Lubricant on end of valve and install dust cover.

WARNING: Use care when turning adjusting nut. Use long extension shaft(s) on socket when turning adjusting nut and BE CAREFUL not to place hands in a position where they could be injured by cable adaptor movement.

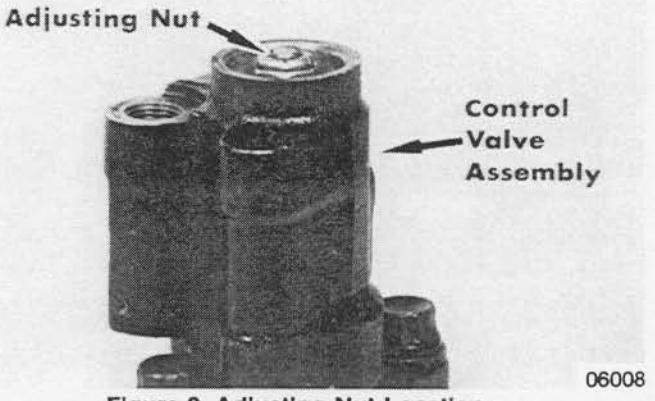


Figure 3. Adjusting Nut Location

POWER STEERING PUMP

DESCRIPTION

Hydraulic pump is engine-driven vane-type that is not repairable and must be replaced if defective.

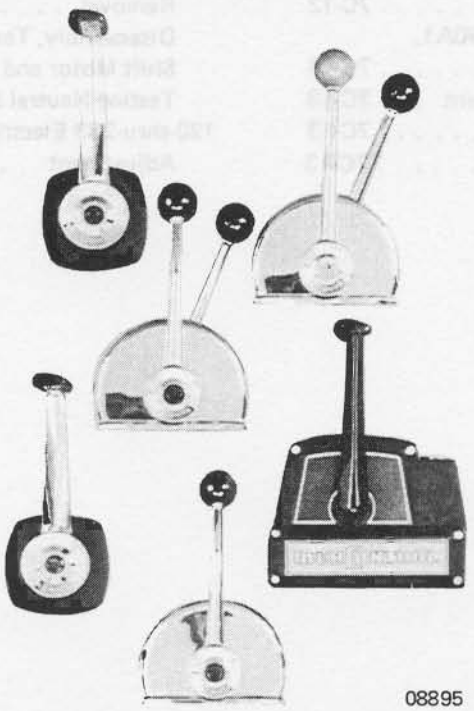
REMOVAL and INSTALLATION

1. Disconnect hoses at pump. When hoses are disconnected, secure ends in raised position to prevent loss of oil. Cap with plug or tape ends of hoses to prevent entrance of dirt.
2. Install 2 caps or plugs at hose fittings to prevent loss of oil from pump.
3. Loosen belt tension brace nut and bolt where brace attaches to pump brace bracket.
4. Loosen and remove pump drive belt.
5. Remove pump from pump mounting bracket.

SECTION 7 - ACCESSORIES

MERCRUISER

PART C - REMOTE CONTROLS



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MERCURY MARINE

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MERCONTROL B-45958A5

SHIFT and THROTTLE CABLE REPLACEMENT

IMPORTANT: In order to assure proper operation of remote control, adhere to the following:

- Control cables must be correct length. Cables, which are too short or too long, will cause hard shifting and throttle action.
- Cables should follow the shortest route to stern drive unit and engine.
- Bends should be kept to a minimum and not form less than a 12" (30.48cm) radius.
- Cables C-34555A_ must be used with this control.
- These cables are available in lengths of 3 ft. to 40 ft. by 1 ft. increments; i.e., 5, 6, 7, 8, etc. Longer cables are available on special order. (In metric table, 1 ft. is equal to 30.48cm.)

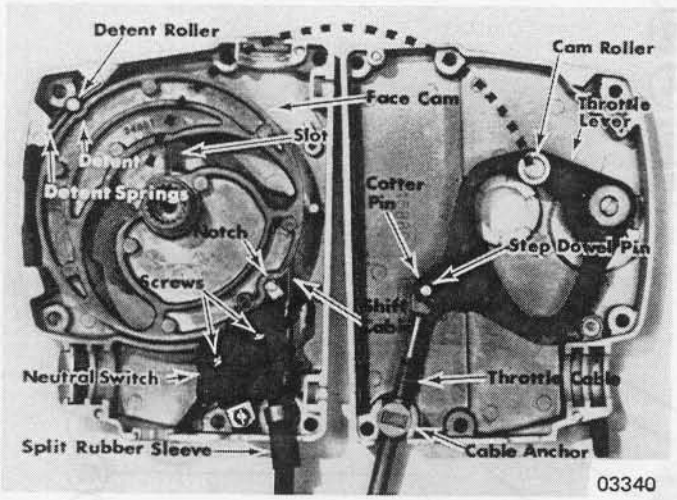


Figure 1. Control Halves

SHIFT CABLE

1. Remove handle, then remove 4 screws and separate control housing halves.
2. Remove detent spring and detent roller. (Figure 1)
3. Move neutral safety switch out of position. (Figure 1)
4. Lift face cam out of housing.

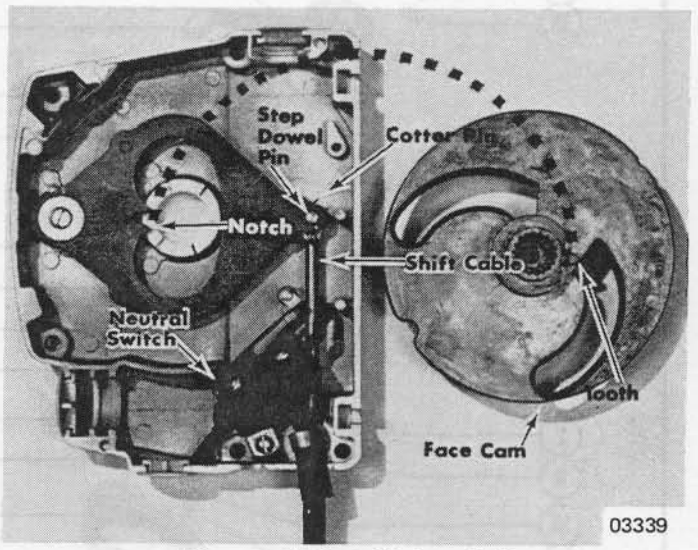


Figure 2. Shift Cable Installed

NOTE: Install control cable C-34555A_ of desired length. Before installing, make sure that set screws in end guides are tight.

5. Remove dowel pin from shift lever to remove shift cable. (Figure 2)
6. Place Anti-Corrosion Grease (C-92-63290) into cable socket before installing shift cable.

NOTE: Be sure that neutral safety switch is aligned with notch of face cam. (Figure 1) Position split rubber sleeves on neutral switch cable over ends of shift and throttle cable plastic barrels to keep cables in position.

THROTTLE CABLE

1. Remove dowel pin from throttle lever and remove throttle cable. (Figure 1)
2. Place Anti-Corrosion Grease into cable socket before installing throttle cable.

REASSEMBLY of CONTROL (Figure 3)

1. Before placing halves together, be sure that face cam and throttle lever are positioned as shown in Figure 1.
2. Place halves together. If housing halves do not fit together, cam roller is not entering face cam slot. Reposition as in Figure 1.
3. Place screws thru housing halves and tighten evenly.
4. Set handle into splined hub on desired side and turn until detent (neutral position) is noted. Reset handle so that handle is in vertical position. (Figure 4) Install handle screw and lockwasher and tighten securely.
5. Hand grip may be repositioned on control handle.
6. Fasten control cables to boat with clamps, "D" washers and screw. Allow cables to protrude straight back from control assembly and do not fasten to boat for at least 3 ft. (91cm) from control. This will prevent placing a load or bind on cables.

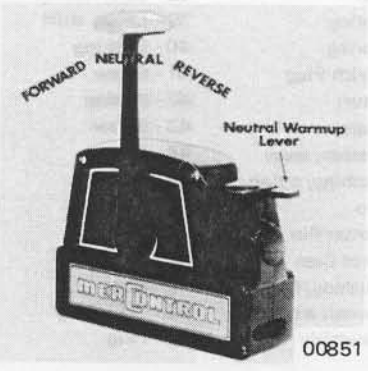
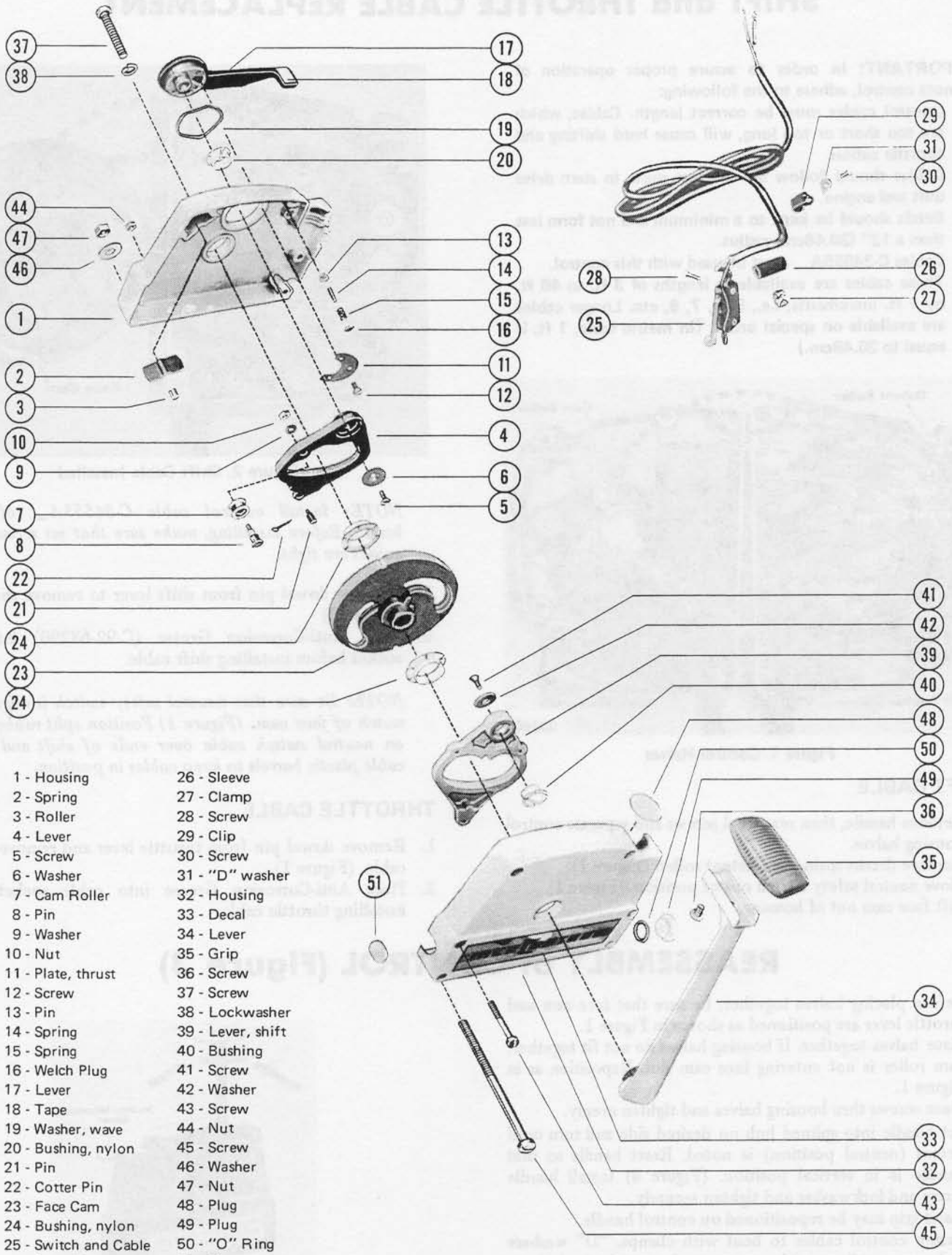


Figure 4. Control Handle Positions



1 - Housing
2 - Spring
3 - Roller
4 - Lever
5 - Screw
6 - Washer
7 - Cam Roller
8 - Pin
9 - Washer
10 - Nut
11 - Plate, thrust
12 - Screw
13 - Pin
14 - Spring
15 - Spring
16 - Welch Plug
17 - Lever
18 - Tape
19 - Washer, wave
20 - Bushing, nylon
21 - Pin
22 - Cotter Pin
23 - Face Cam
24 - Bushing, nylon
25 - Switch and Cable Assembly
26 - Sleeve
27 - Clamp
28 - Screw
29 - Clip
30 - Screw
31 - "D" washer
32 - Housing
33 - Decal
34 - Lever
35 - Grip
36 - Screw
37 - Screw
38 - Lockwasher
39 - Lever, shift
40 - Bushing
41 - Screw
42 - Washer
43 - Screw
44 - Nut
45 - Screw
46 - Washer
47 - Nut
48 - Plug
49 - Plug
50 - "O" Ring
51 - Plug

Figure 3. Remote Control, Exploded View

CABLE ADJUSTMENT

Refer to "Removal-Installation-Alignment" Section 2 for shift and throttle cable adjustment.

REPLACING BARREL on C-34555A CABLE (Figure 5)

NOTE: Late cables have molded-on barrels that cannot be replaced.

If nylon barrel on remote control cable C-34555A__becomes loose or damaged, replace as follows:

NOTE: Remove burrs (made by set screws on core wire) with a file so that inner lining of cable will not be damaged when core wire is removed. Round off end of core wire so that inner lining is not damaged when core wire is reinserted.

1. Remove inner core wire.
2. Remove damaged barrel.
3. Install new brass barrel assembly (C-38685A1). Larger diameter of hole in barrel faces cable.
4. Distance from end of cable to centerline of brass barrel assembly must measure exactly 1-3/8" (3.5cm). (Figure 5)

NOTE: Brass barrel assembly must be staked or locked in place with Loctite Type "A" (C-92-32609).

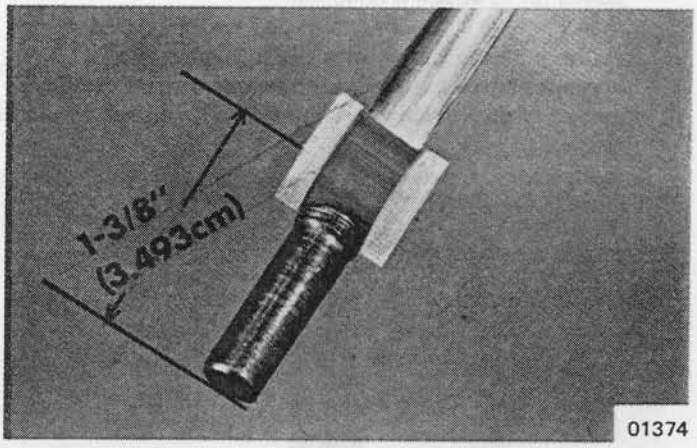


Figure 5. Distance from Cable End to Center of Brass Barrel

REPLACING INNER CORE WIRE for C-34555A_CABLE

The replacement inner core wire assembly (C-36201A40 for C-34555A__remote control cable) has the stainless steel terminal end installed and is available only in 40 ft. (12.2m) lengths.

1. Loosen set screws and remove cable end.
2. Remove burrs (made by set screws on core wire) with file so that inner lining of cable will not be damaged when core wire is removed. Remove core wire.

INSTALLATION

1. Round off end (without terminal end) of new wire to prevent damaging inner liner of cable when wire is inserted.
2. Lubricate inner core wire with Multipurpose Lubricant (C-92-63250) while sliding into outer cable.
3. Continue to insert core wire until able to grip opposite end.
4. Pull core wire until distance from centerline of hole in steel terminal end and centerline of brass barrel measures exactly 2-7/16" (6.19cm). (Figure 6)
5. Measure exactly 4" (10.16cm) from end of cable insert and cut off excess core wire. (Figure 6)
6. Install cable end guide to core wire. Tighten screws securely.

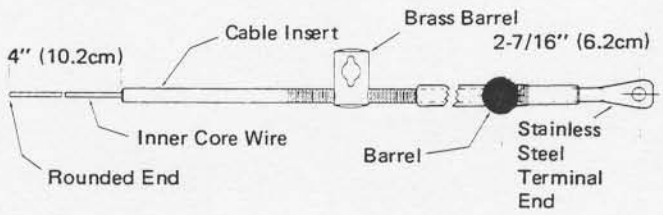


Figure 6. C-34555A__ Remote Control Cable

MERCONTROL C-37782A1-A2 and B-64326A1-A3

SHIFT and THROTTLE CABLE REPLACEMENT

REMOVING CONTROL HANDLE and CONTROL

NOTE: If button is thread-on type, remove button before removing handle. If button is push-on type, button can be pulled off as handle is removed.

1. Remove button from control shaft. (Figure 1)
2. Loosen set screw in handle and remove control handle.
3. Remove screws which hold bezel and control to panel. (Figure 2)

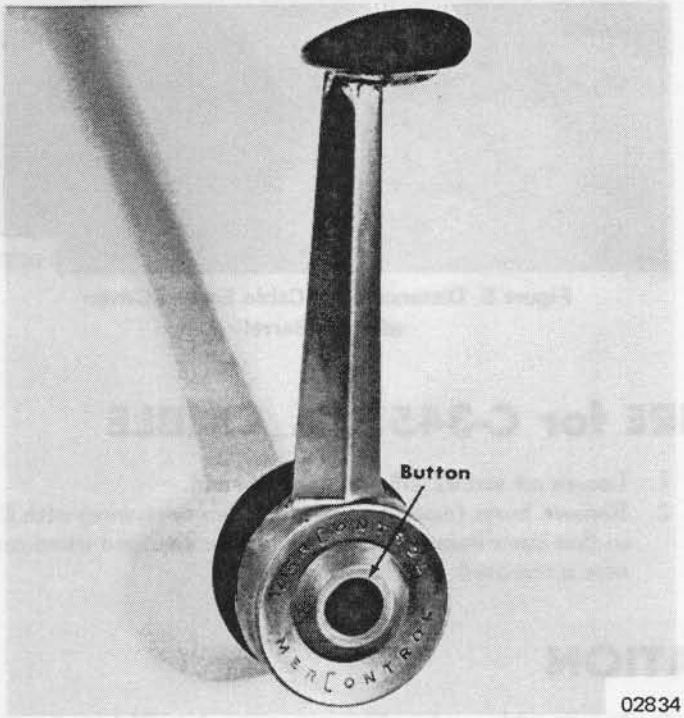


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Figure 1. Control Handle

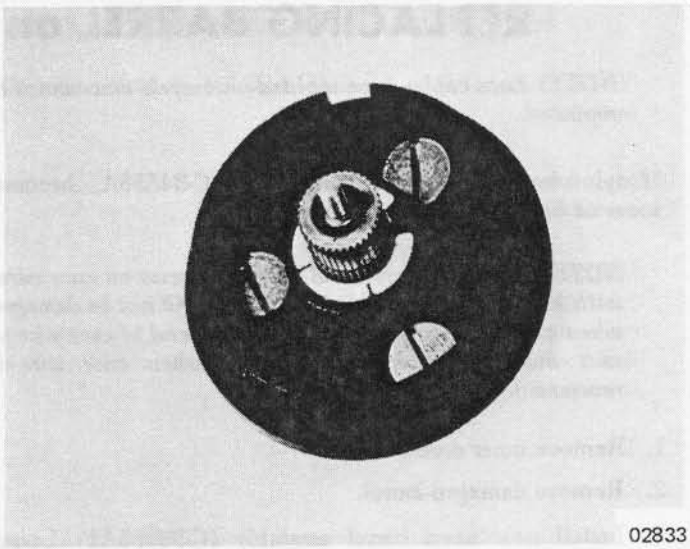

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Figure 2. Bezel Installed

4. Control and control cables may be removed.

IMPORTANT: In order to assure proper operation of remote control, adhere to the following:

- **Control cables must be correct length. Cables, which are too long or too short, will cause hard shifting and throttle action.**
- **Bends should be kept to a minimum and not form less than a 12" (30.48cm) radius.**
- **Cables should follow the shortest route to stern drive unit and engine.**
- **Cables C-34555A__ must be used with this control.**
- **These cables are available in lengths of 3 ft. (1.5m) to 40 ft. (12.2m) by 1 ft. (.3m) increments, i.e., 5, 6, 7, 8, etc. Longer cables are available on special order.**

CABLE REPLACEMENT

NOTE: It is not necessary to disassemble control housing to install control cables. Cable replacement procedures are the same for port or starboard controls.

1. Remove cotter pins and covers. (Figure 3)
2. Place handle on splined shaft and move handle approximately 45° toward reverse position and remove handle.

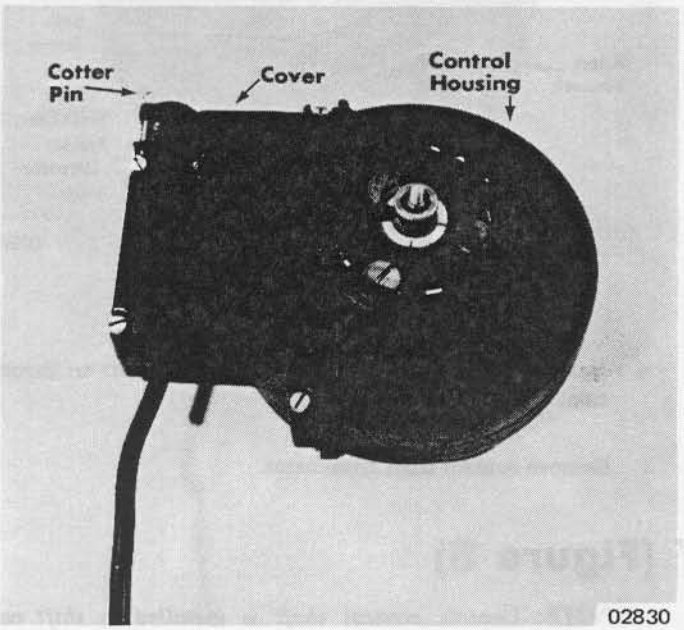


Figure 3. Cotter Pin and Cover Location

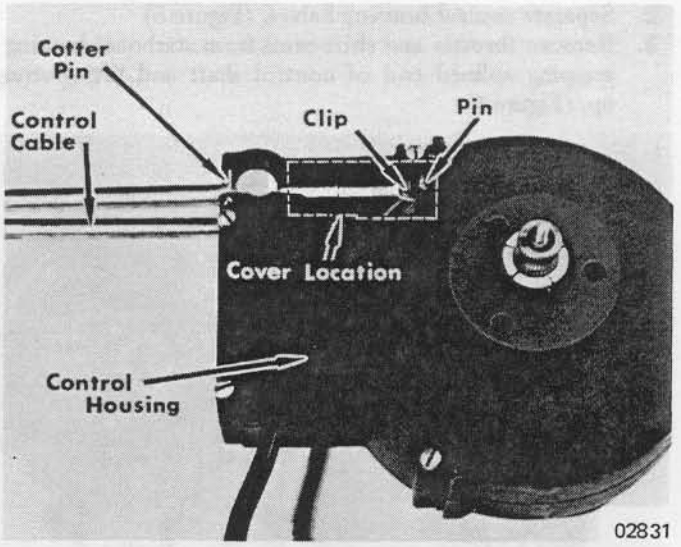


Figure 4. Control Cables Installed in Control Housing

This will position shift and throttle levers so that control cables can be removed or installed.

3. Control cables are held in position with pins and hair pin clips. (Figure 4)

NOTE: Port control throttle cable is on side furthest from control handle and starboard throttle cable is on side nearest control handle.

4. Reinstall covers and cotter pins in control housing.

REMOVING CONTROL SHAFTS

1. Remove screws which fasten control housing halves.
2. Separate control housing halves. (Figure 5)
3. Remove throttle and shift cams from starboard housing by grasping splined end of control shaft and lifting straight up. (Figure 5)

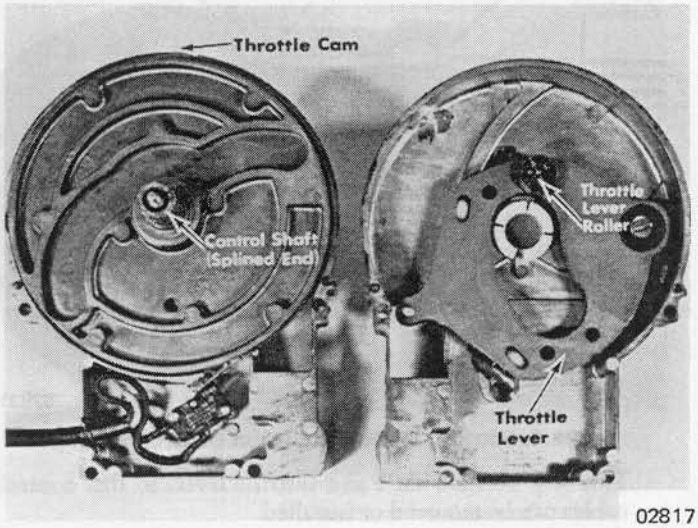


Figure 5. Control Housing Separated

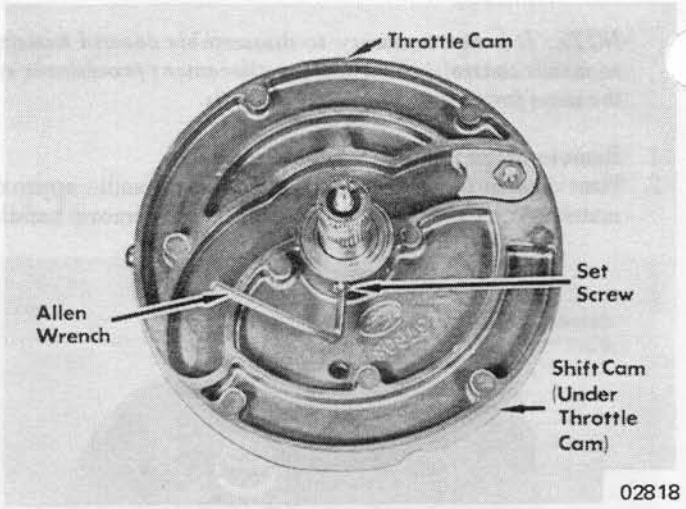


Figure 6. Loosening Set Screw

4. Remove set screw which secures control shaft to throttle cam. (Figure 6)
5. Remove control shaft from cams.

REASSEMBLY (Figure 8)

1. Reassemble in the reverse order of disassembly.
2. Lubricate nylon bushings with Multipurpose Lubricant (C-92-63250).

NOTE: Console control shaft is installed in shift car either way for left or right side control handle location.

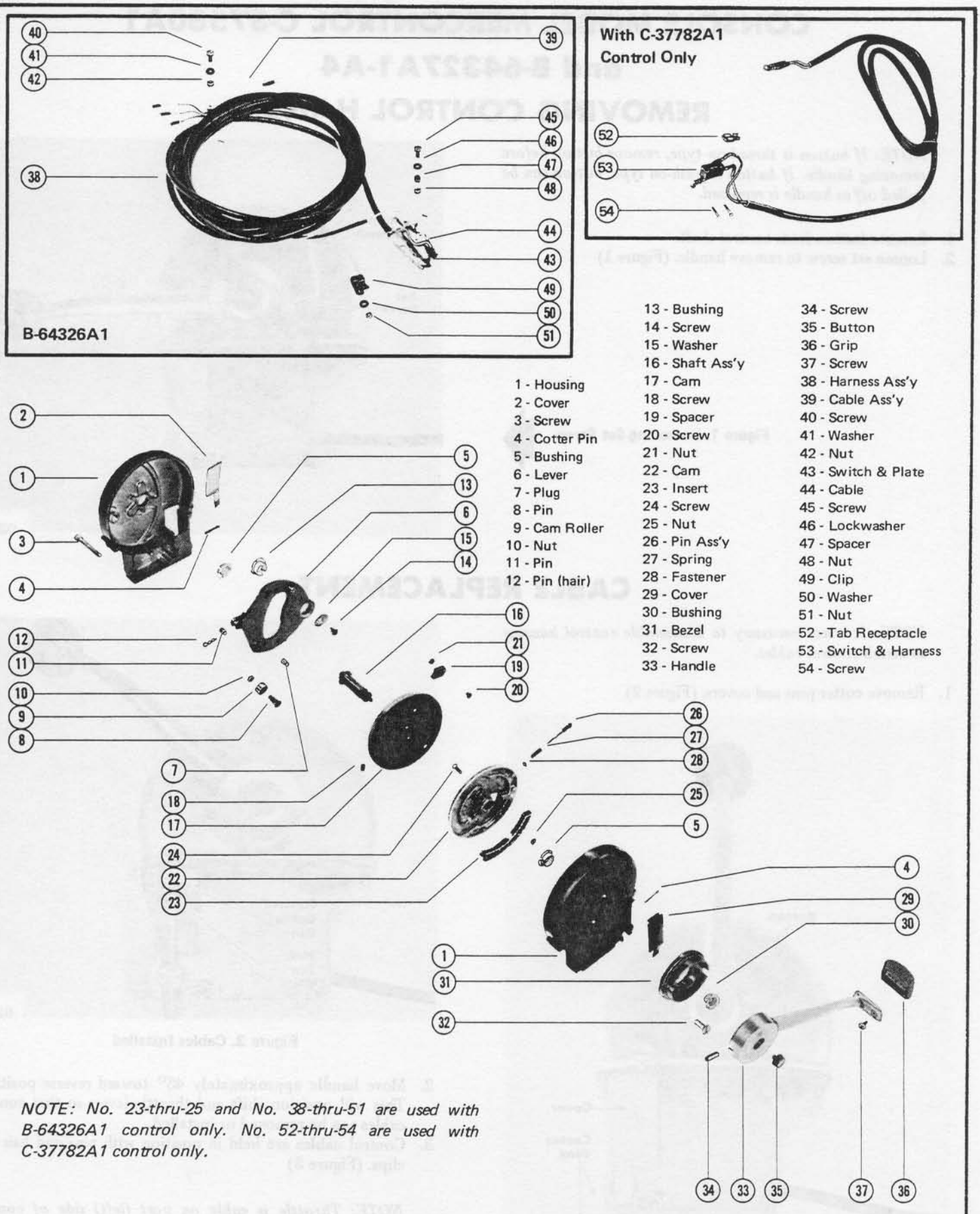
CABLE ADJUSTMENT

Refer to "Removal-Installation-Alignment" Section 2 for shift and throttle cable adjustment.

TESTING ELECTRIC SHIFT SWITCHES (B-64326A1-A3 CONTROL)

CAUTION: Disconnect battery leads from battery before attempting any of the following steps.

1. Disconnect control shift harness white lead at instrumentation and control shift harness leads from shift motor.
2. Connect continuity meter (or continuity light) between remote control white lead and metal portion of control box (ground).
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement. If meter indicates closed circuit or meter movement, switch(es) or harness has a short.
3. Connect continuity meter (or continuity light) between remote control white lead and blue lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate closed circuit or meter movement.
4. Connect continuity meter (or continuity light) between remote control white lead and orange lead.
   a. Neutral - Meter should indicate closed circuit or meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
5. Connect continuity meter (or continuity light) between remote control white and green lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate closed circuit or meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
6. For connecting shift wires to engine, refer to "Removal-Installation-Alignment" Section 2.
7. Push in warm-up button and shift to full forward. Button must stay engaged. Connect continuity meter (or continuity light) to remote control white lead and other meter leads alternately to blue, orange, green wires and metal portion of control box (ground). Meter should indicate open circuit or no meter movement at all lead connections and ground.



NOTE: No. 23-thru-25 and No. 38-thru-51 are used with B-64326A1 control only. No. 52-thru-54 are used with C-37782A1 control only.

Figure 8. Remote Control, Exploded View

CONSOLE MODEL MERCONTROL C-37580A1 and B-64327A1-A4

REMOVING CONTROL HANDLE

NOTE: If button is thread-on type, remove button before removing handle. If button is push-on type, button can be pulled off as handle is removed.

1. Remove button from control shaft.
2. Loosen set screw to remove handle. (Figure 1)

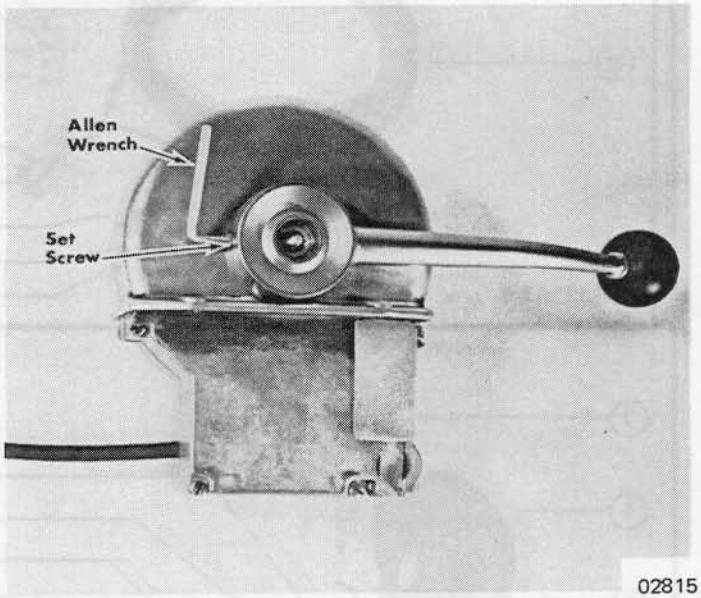


Figure 1. Loosening Set Screw

CABLE REPLACEMENT

NOTE: It is not necessary to disassemble control housing to install control cables.

1. Remove cotter pins and covers. (Figure 2)

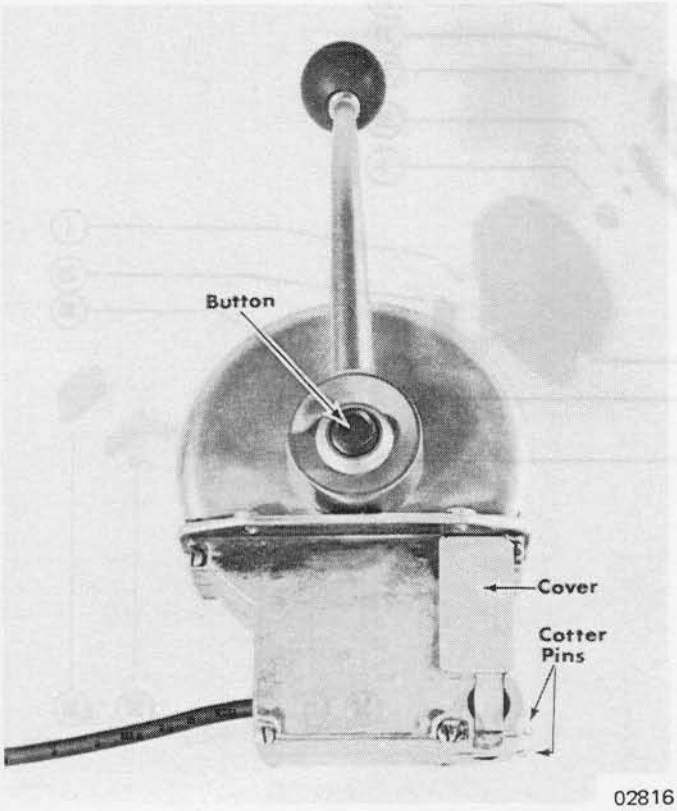


Figure 2. Control Button Installed

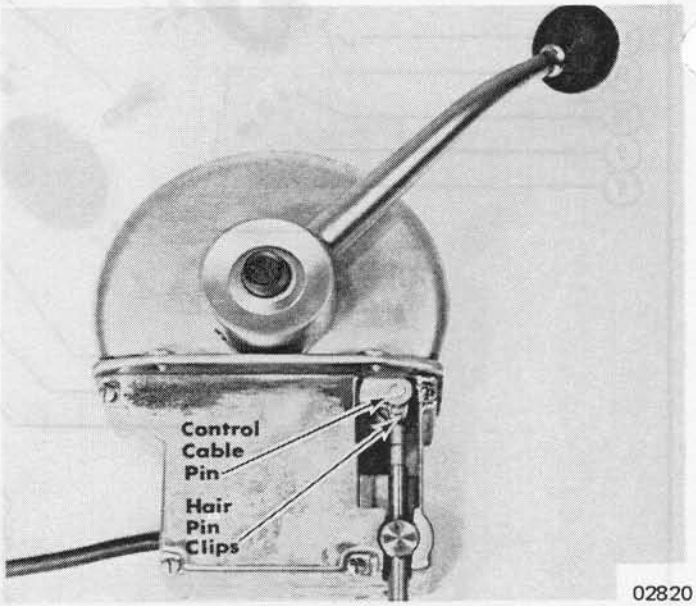


Figure 3. Cables Installed

2. Move handle approximately 45° toward reverse position. This will position shift and throttle levers so that control cables can be removed or installed.
3. Control cables are held in position with pins and hair pin clips. (Figure 3)

   NOTE: Throttle is cable on port (left) side of control housing.

4. Reinstall covers and cotter pins in control housing.

LUBRICATION

Lubricate panel controls and console controls in area where blocking pin roller rides on housing before assembling control housings. Also lubricate this area with Quicksilver Anti-Corrosion Grease (C-92-63290) when servicing these controls.

CABLE ADJUSTMENT

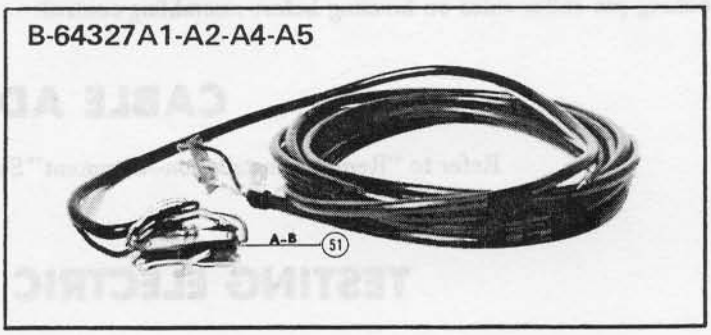
Refer to "Removal-Installation-Alignment" Section 2 for shift and throttle cable adjustment.

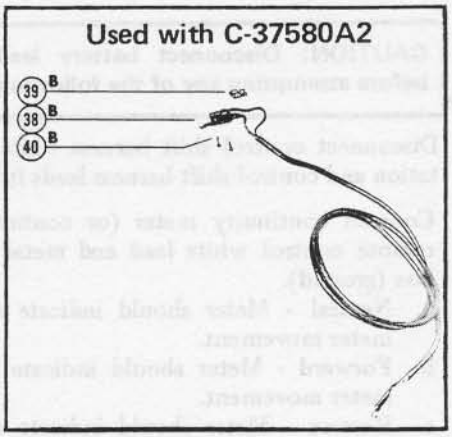
TESTING ELECTRIC SHIFT SWITCHES

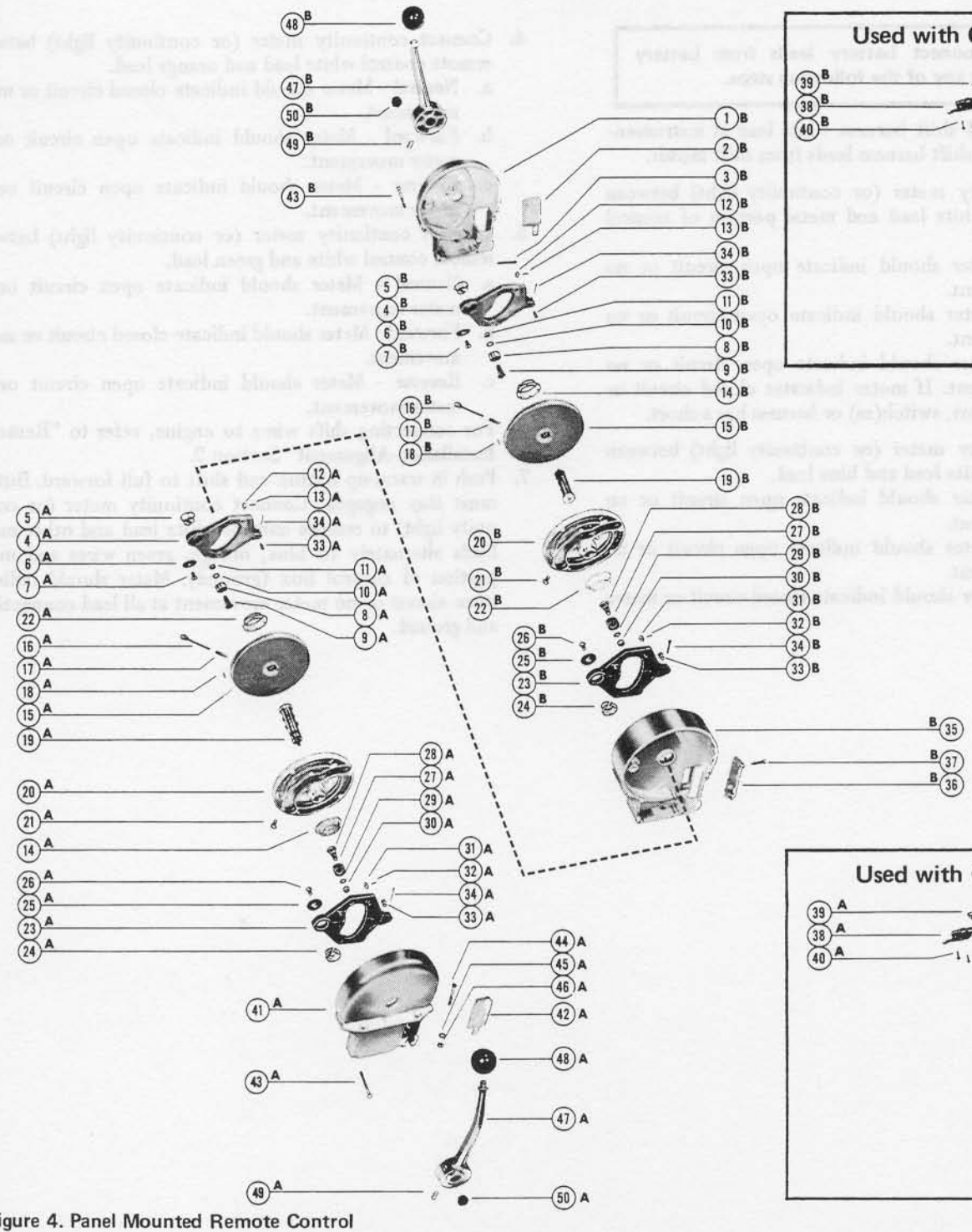
CAUTION: Disconnect battery leads from battery before attempting any of the following steps.

1. Disconnect control shift harness white lead at instrumentation and control shift harness leads from shift motor.
2. Connect continuity meter (or continuity light) between remote control white lead and metal portion of control box (ground).
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement. If meter indicates closed circuit or meter movement, switch(es) or harness has a short.
3. Connect continuity meter (or continuity light) between remote control white lead and blue lead..
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate closed circuit or meter movement.
4. Connect continuity meter (or continuity light) between remote control white lead and orange lead.
   a. Neutral - Meter should indicate closed circuit or meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
5. Connect continuity meter (or continuity light) between remote control white and green lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate closed circuit or meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
6. For connecting shift wires to engine, refer to "Removal-Installation-Alignment" Section 2.
7. Push in warm-up button and shift to full forward. Button must stay engaged. Connect continuity meter (or continuity light) to remote control white lead and other meter leads alternately to blue, orange, green wires and metal portion of control box (ground). Meter should indicate open circuit or no meter movement at all lead connections and ground.

MerControl C-37580A1 and B-64327A1-A4 Use Numbers with Suffix "A".
MerControl C-37580A2 and B-64327A1-A5 Use Numbers with Suffix "A" and "B".







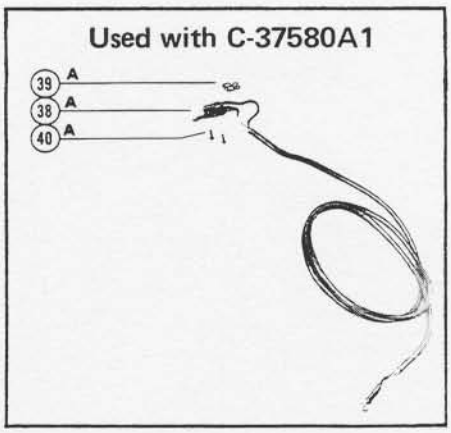


Figure 4. Panel Mounted Remote Control

1 - Housing, remote control (starboard)
2 - Cover, control housing (starboard)
3 - Cotter Pin
4 - Lever, shift
5 - Bushing, nylon - shift lever
6 - Washer, retaining
7 - Screw
8 - Cam Roller, shift lever
9 - Pin, cam roller to shift lever
10 - Washer, cam roller pin
11 - Nut, cam roller pin
12 - Roller Guide, shift lever
13 - Pin, roller guide to shift lever
14 - Bushing, nylon
15 - Cam, shift
16 - Pin Assembly, blocking - shift cam
17 - Spring, compression - blocking pin
18 - Fastener - blocking pin to shift cam
19 - Shaft Assembly, control
20 - Cam, throttle
21 - Screw, set - throttle cam
22 - Bushing, nylon
23 - Lever, throttle
24 - Bushing, nylon
25 - Washer, retaining
26 - Screw
27 - Cam Roller, throttle lever
28 - Pin, cam roller to throttle lever
29 - Washer, cam roller pin
30 - Nut, cam roller pin
31 - Roller Guide, throttle lever
32 - Pin, roller guide to throttle lever
33 - Pin
34 - Pin (hair), control cable pin
35 - Housing, remote control (center)
36 - Plate, retainer - center housing
37 - Screw, retainer plate to center hsg.
38 - Switch and Harness Assembly, safety
39 - Tab Receptacle, safety switch
40 - Screw, safety switch to control hsg.
41 - Housing, remote control (port)
42 - Cover, control housing (port)
43 - Screw, control housing clamping
44 - Screw, remote control to boat
45 - Washer, remote control screw
46 - Nut, remote control screw
47 - Handle, control
48 - Grip, control handle (black)
49 - Screw, set
50 - Button, control handle
51 - Switch and Harness Assembly

(Parts' Description for Figure 4, preceding)

DUAL CONSOLE MERCONTROL C-37580A2 and B-64327A2-A5 SHIFT and THROTTLE CABLE REPLACEMENT

NOTE: It is not necessary to disassemble control housing to install control cables.

1. Remove cotter pins and covers, screws and center cover.
2. Move both control handles to vertical (neutral) position. (Figure 1)

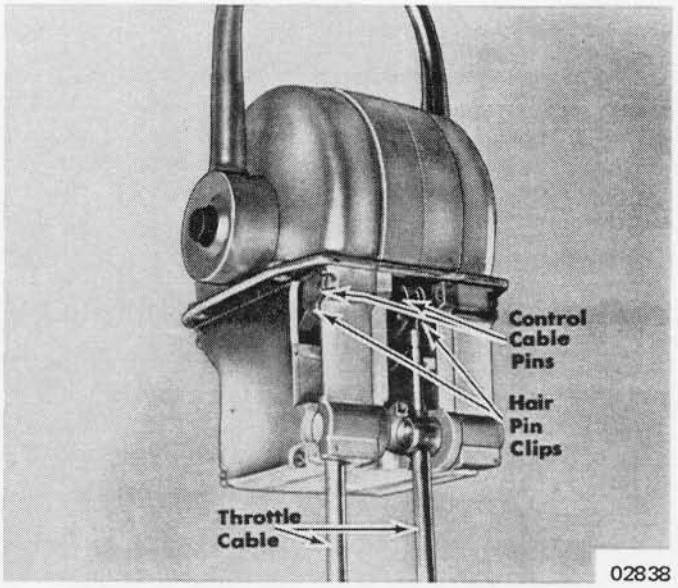


Figure 1. Throttle Cables Installed

3. Throttle cables are held in position with cable pin and hair pin clip. (Figure 2)
4. Move both control handles to reverse position.
5. Shift cables are held in position with pins and hair pin clips.
6. Reinstall cotter pins, covers and screws. (Figure 3)
7. Reassemble in reverse order of disassembly, preceding. (Figure 4)

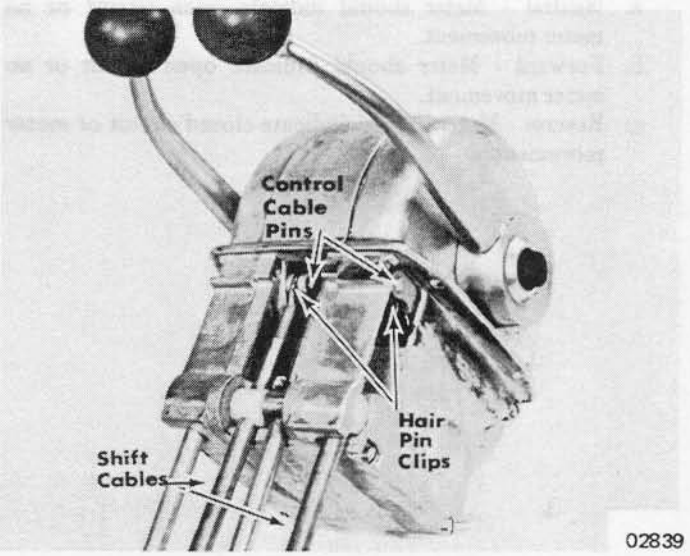


Figure 2. Shift Cables Installed

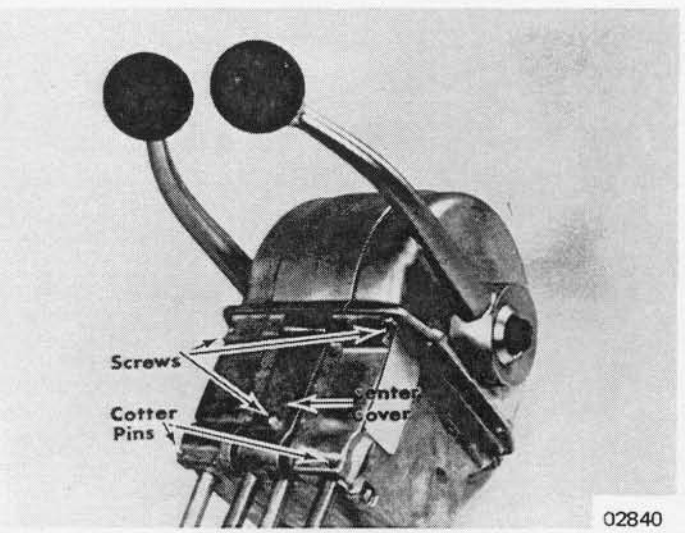


Figure 3. Covers Installed

CABLE ADJUSTMENT

Refer to "Removal-Installation-Alignment" Section 2 for shift and throttle cable adjustment.

TESTING ELECTRIC SHIFT SWITCHES

CAUTION: Disconnect battery leads from battery before attempting any of the following steps.

1. Disconnect control shift harness white lead at instrumentation and control shift harness leads from shift motor.
2. Connect continuity meter (or continuity light) between remote control white lead and metal portion of control box (ground).
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement. If meter indicates closed circuit or meter movement, switch(es) or harness has a short.
3. Connect continuity meter (or continuity light) between remote control white lead and blue lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate closed circuit or meter movement.
4. Connect continuity meter (or continuity light) between remote control white lead and orange lead.
   a. Neutral - Meter should indicate closed circuit or meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
5. Connect continuity meter (or continuity light) between remote control white and green lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate closed circuit or meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
6. For connecting shift wires to engine, refer to "Removal-Installation-Alignment" Section 2.
7. Push in warm-up button and shift to full forward. Button must stay engaged. Connect continuity meter (or continuity light) to remote control white lead and other meter leads alternately to blue, orange, green wires and metal portion of control box (ground). Meter should indicate open circuit or no meter movement at all lead connections and ground.

TWO-LEVER CONSOLE MODEL MERCONTROL C-38290A1, C-58602A1 and B-63064A1 SHIFT and THROTTLE CONTROL CABLE REPLACEMENT

NOTE: It is not necessary to disassemble control housing to install control cables.

1. Remove cotter pins and covers. (Figure 1)
2. Move throttle handle to idle position and shift handle to reverse position. This will position shift and throttle levers so that control cables can be removed and/or installed.

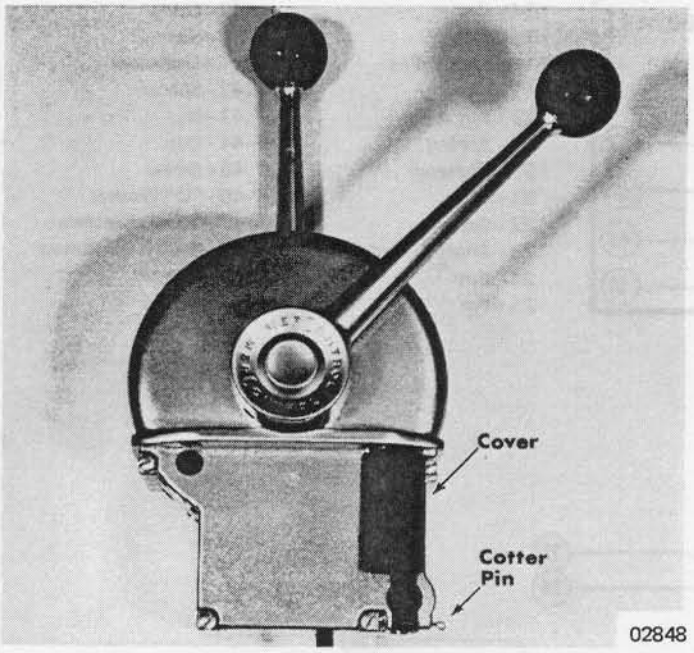


Figure 1. Removing Covers

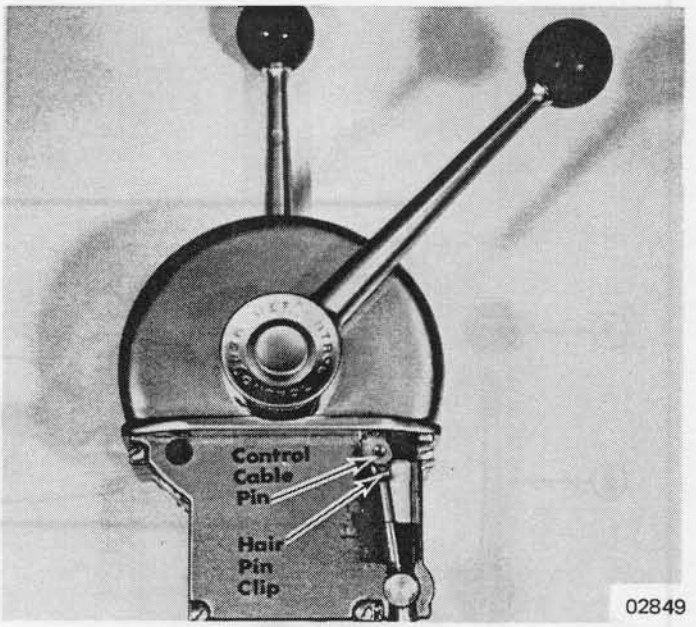


Figure 2. Cables Installed

3. Control cables are held in position with pins and hair pin clips. (Figure 2)

   NOTE: Throttle is cable on port (left) side of control housing.

4. Reinstall covers and cotter pins.

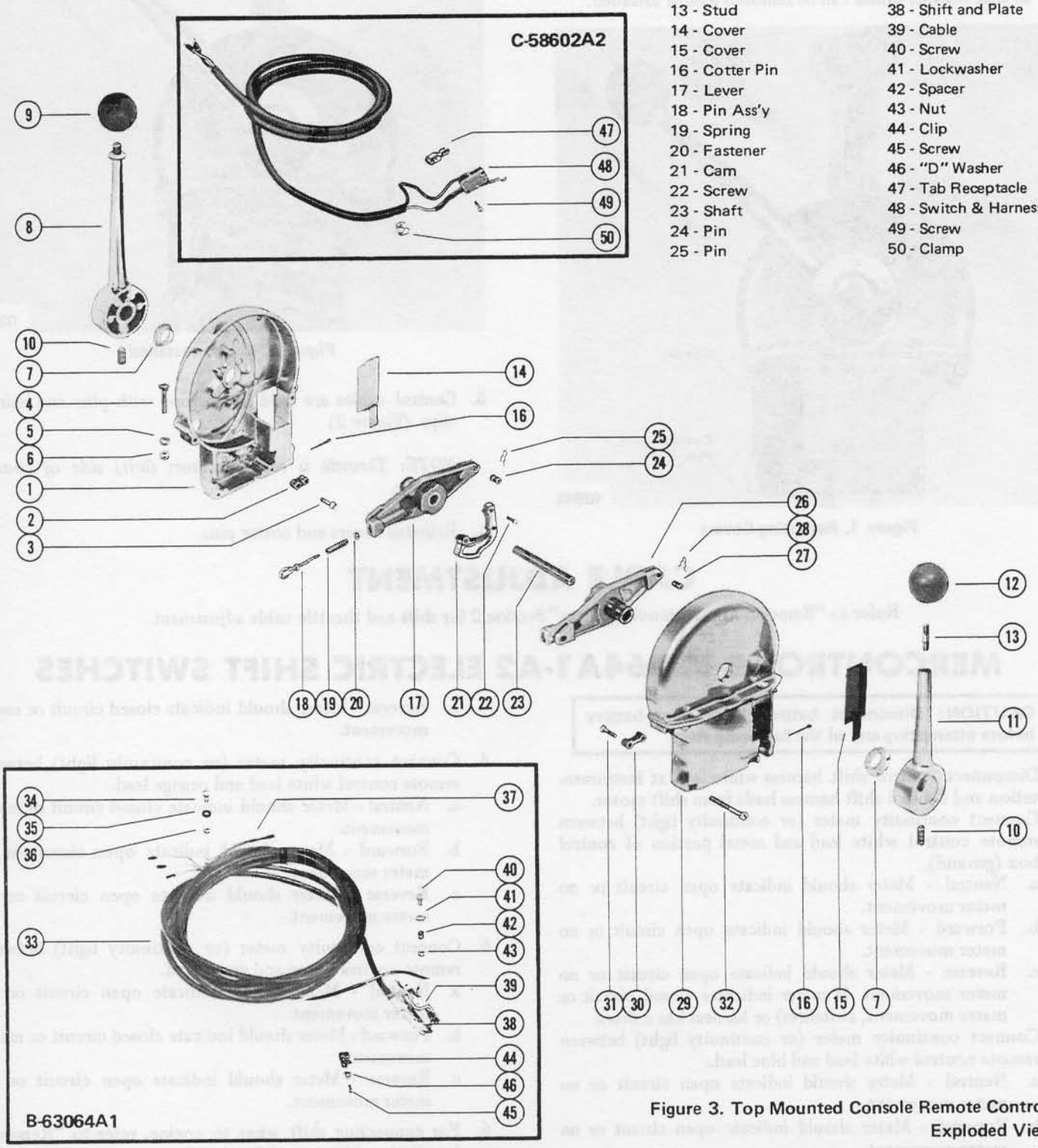
CABLE ADJUSTMENT

Refer to "Removal-Installation-Alignment" Section 2 for shift and throttle cable adjustment.

MERCONTROL B-63064A1-A2 ELECTRIC SHIFT SWITCHES

CAUTION: Disconnect battery leads from battery before attempting any of the following steps.

1. Disconnect control shift harness white lead at instrumentation and control shift harness leads from shift motor.
2. Connect continuity meter (or continuity light) between remote control white lead and metal portion of control box (ground).
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement. If meter indicates closed circuit or meter movement, switch(es) or harness has a short.
3. Connect continuity meter (or continuity light) between remote control white lead and blue lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate closed circuit or meter movement.
4. Connect continuity meter (or continuity light) between remote control white lead and orange lead.
   a. Neutral - Meter should indicate closed circuit or meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
5. Connect continuity meter (or continuity light) between remote control white and green lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate closed circuit or meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
6. For connecting shift wires to engine, refer to "Removal-Installation-Alignment" Section 2.



1 - Housing
2 - Block
3 - Screw
4 - Screw
5 - Washer
6 - Nut
7 - Bushing
8 - Handle
9 - Knob
10 - Screw
11 - Handle
12 - Knob
13 - Stud
14 - Cover
15 - Cover
16 - Cotter Pin
17 - Lever
18 - Pin Ass'y
19 - Spring
20 - Fastener
21 - Cam
22 - Screw
23 - Shaft
24 - Pin
25 - Pin
26 - Lever
27 - Pin
28 - Pin
29 - Housing
30 - Block
31 - Screw
32 - Screw
33 - Harness Ass'y
34 - Screw
35 - Washer
36 - Nut
37 - Cable Ass'y
38 - Shift and Plate
39 - Cable
40 - Screw
41 - Lockwasher
42 - Spacer
43 - Nut
44 - Clip
45 - Screw
46 - "D" Washer
47 - Tab Receptacle
48 - Switch & Harness
49 - Screw
50 - Clamp

Figure 3. Top Mounted Console Remote Control, Exploded View

DUAL STATION CONTROL KIT C-38290A2
TWO-LEVER CONSOLE MOUNTED MERCONTROL
DUAL STATION (Single Motor)
SHIFT and THROTTLE CONTROL CABLE REPLACEMENT

CONTROL STATION NO. 1

1. Use two C-38286A__control cables of desired length.
2. Remove cotter pins and covers from control housing. (Figure 1)
3. Move throttle handle to idle position and shift handle to reverse position. This will position shift and throttle levers so that control cables can be installed.

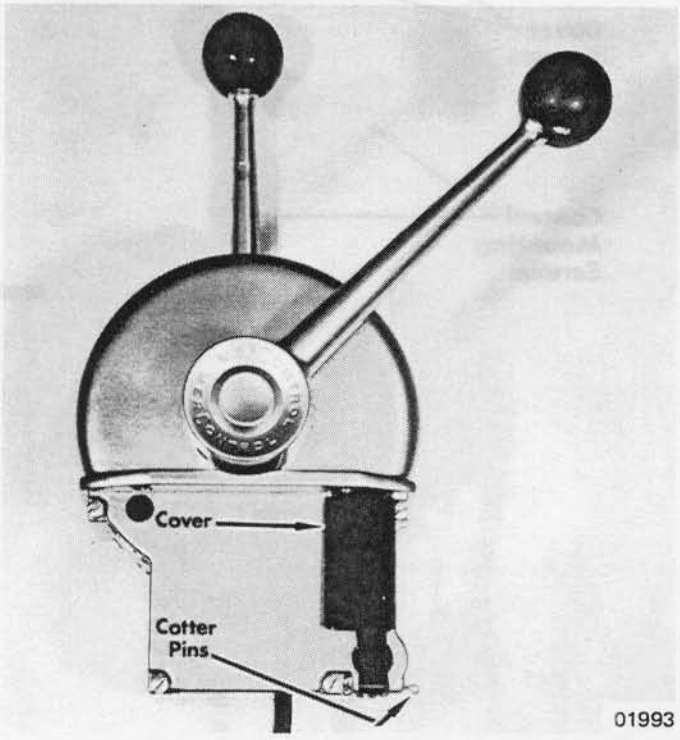


Figure 1. Cotter Pins and Cover Location

4. Position control cables in control housing and install control cable pins and hair pin clips. (Figure 2)

   NOTE: Throttle cable is on port (left) side of control housing.

5. Reinstall covers and cotter pins in control housing.

CONTROL STATION NO. 2

1. Use two C-38286A__control cables of desired length.
2. Move throttle handle to fast position and shift handle to forward position. This will position throttle and shift levers so that control cables can be removed or installed.
3. Control cables are held in position with pins and hair pin clips. (Figure 3)

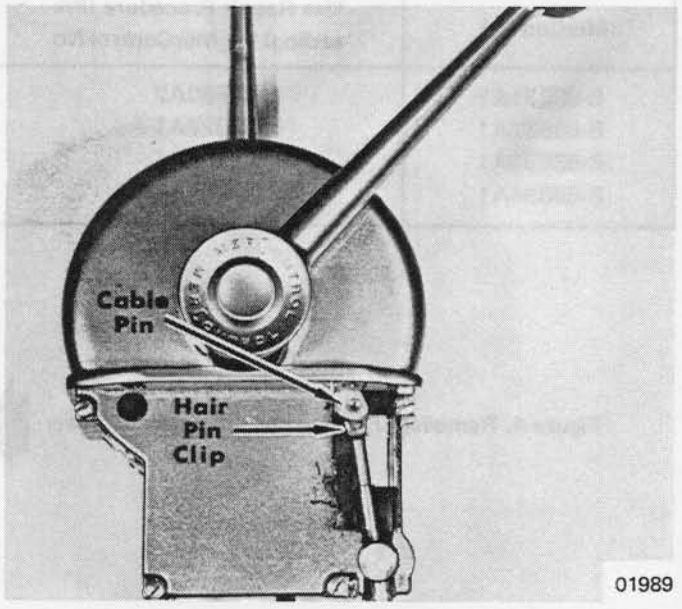


Figure 2. Pins and Clips Location

NOTE: Throttle cable is on port (left) side of control.

IMPORTANT: Electric Shift (B-70260A1) is required with a dual station control kit.

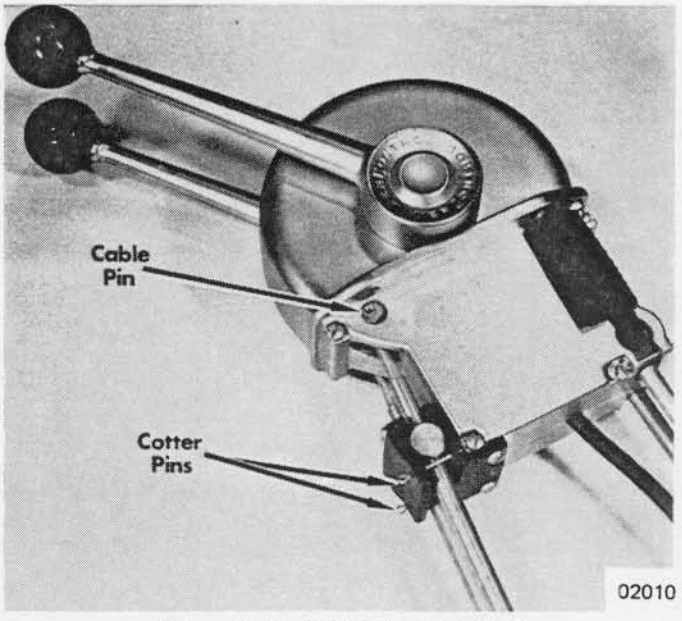


Figure 3. Control Cables Installed

CABLE ADJUSTMENT

Refer to "Removal-Installation-Alignment" Section 2 for shift and throttle cable adjustment.

MERCONTROLS B-68831A1, B-68832A1, B-68833A1 and B-68834A1

Use repair procedure indicated in following chart, except for chrome cover removal and installation. Refer to Figure 4, following.

MerControl	Use Repair Procedure (Preceding) for MerControl No.
B-68831A1	B-37580A2
B-68832A1	B-64327A1-A4
B-68833A1	B-58602A1
B-68834A1	B-63064A1-A2

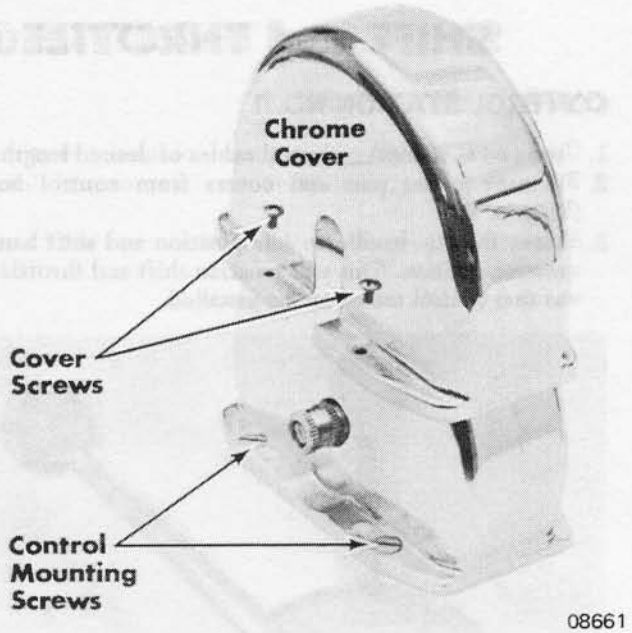


Figure 4. Removal or Installation of Chrome Cover

DELUXE ELECTRIC REMOTE CONTROL B-63063A1 (II-TR and II-TRS) THROTTLE CABLE REPLACEMENT

REMOVAL

1. Remove 3 screws and retaining plate.
2. Remove cotter pin and washer, then throttle cable. (Fig. 1)

REPLACEMENT

1. Place throttle cable end on anchor pin and barrel in recess.
2. Install washer and cotter pin.
3. Install retaining plate with 3 screws.

ADJUSTMENT

Refer to "MerCruiser Removal, Installation and Alignment" Section 2 for throttle cable adjustment.

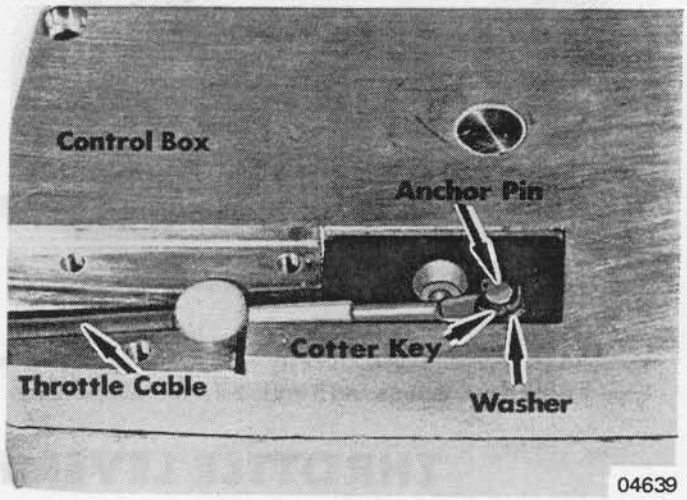


Figure 1. Typical Washer and Cotter Pin Location

DISASSEMBLY

1. With control lever in neutral position, remove lever cover (Figure 2) and 3 screws. Lift connector and remove 3 screws and lever retainer plate. Scribe alignment mark on lever and shaft and pull off control lever.
2. Remove 2 screws in lever, remove plate and pull out rubber boot and switch. (Figure 3) Switches may be unsoldered for replacement.
3. With care, use screwdriver to pry sides and top of plastic case away from housing. Remove case.
4. Remove 2 housing screws (Figure 4) and separate housing halves.
5. Remove 2 cotter pins and remove throttle levers, nyliner and spacer. (Figure 5)

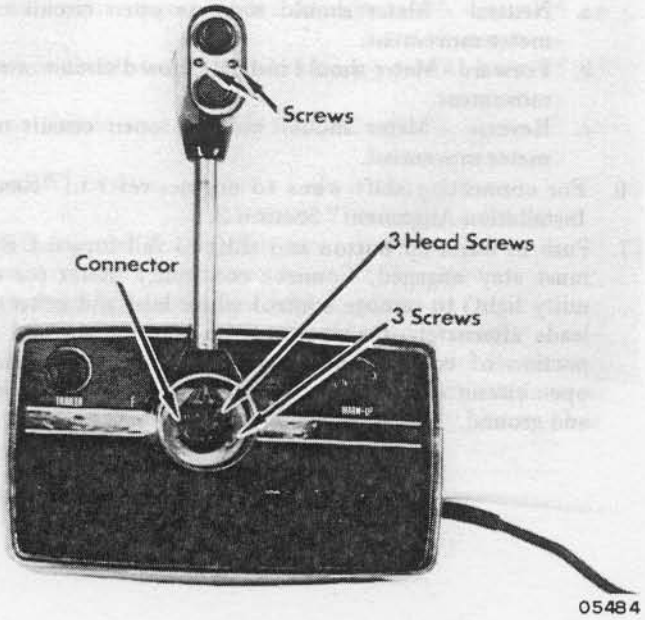


Figure 2. Control Lever Cover Removed

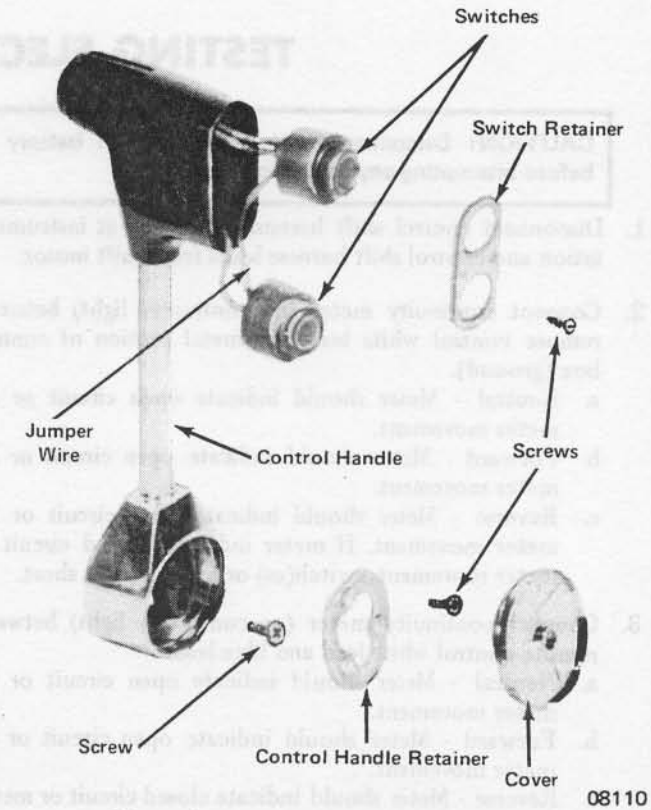


Figure 3. Control Lever Disassembled

6. Remove wires from terminal block, noting position. Remove 2 harness clips and remove trim harness.
7. Remove screws from shift switch. Remove shift switch and throttle cam assembly simultaneously.
8. Remove screws and disassemble throttle cam. (Figure 6)
9. Remove 2 screws and retainer plate and remove "trailer" switch. Switch may be unsoldered for replacement.

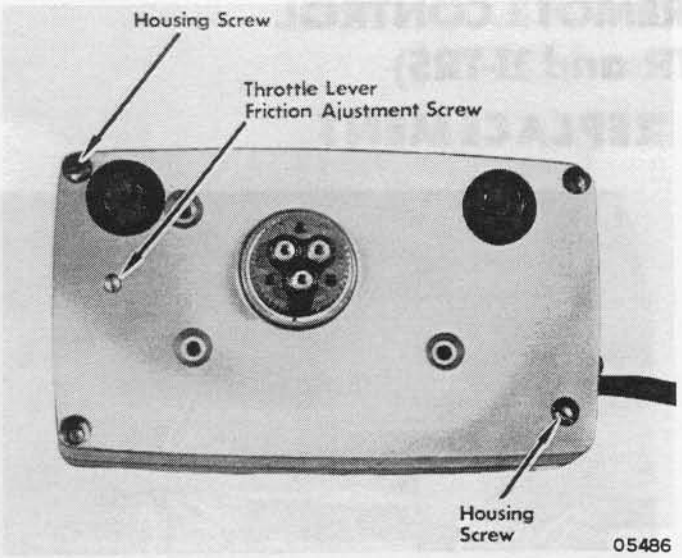


Figure 4. Housing Screws and Throttle Friction Adjustment

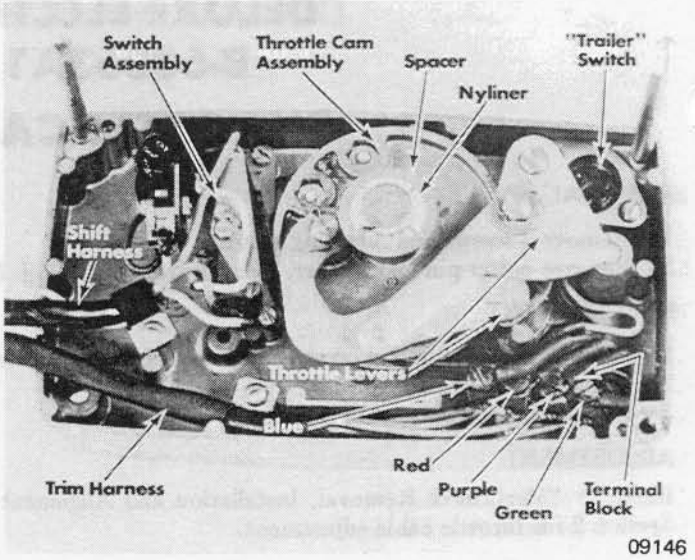


Figure 5. Port Case, Throttle Levers in Position

THROTTLE LEVER FRICTION ADJUSTMENT

Turn friction screw (Figure 4) to attain desired control handle tension.

REASSEMBLY

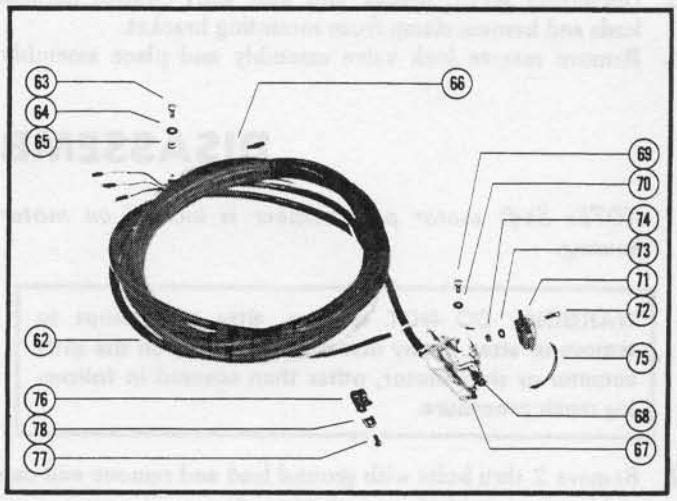
Reassemble control as shown in Figures 2-3-5 and 6.

TESTING ELECTRIC SHIFT SWITCHES

CAUTION: Disconnect battery leads from battery before attempting any of the following steps.

1. Disconnect control shift harness white lead at instrumentation and control shift harness leads from shift motor.
2. Connect continuity meter (or continuity light) between remote control white lead and metal portion of control box (ground).
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement. If meter indicates closed circuit or meter movement, switch(es) or harness has a short.
3. Connect continuity meter (or continuity light) between remote control white lead and blue lead..
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate closed circuit or meter movement.
4. Connect continuity meter (or continuity light) between remote control white lead and orange lead.
   a. Neutral - Meter should indicate closed circuit or meter movement.
   b. Forward - Meter should indicate open circuit or no meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
5. Connect continuity meter (or continuity light) between remote control white and green lead.
   a. Neutral - Meter should indicate open circuit or no meter movement.
   b. Forward - Meter should indicate closed circuit or meter movement.
   c. Reverse - Meter should indicate open circuit or no meter movement.
6. For connecting shift wires to engine, refer to "Removal-Installation-Alignment" Section 2.
7. Push in warm-up button and shift to full forward. Button must stay engaged. Connect continuity meter (or continuity light) to remote control white lead and other meter leads alternately to blue, orange, green wires and metal portion of control box (ground). Meter should indicate open circuit or no meter movement at all lead connections and ground.

1 - Housing Ass'y
2 - Stud
3 - Screw
4 - Nut
5 - Housing
6 - Cover
7 - Screw
8 - Detent Pin
9 - Lever
10 - Washer
11 - Cotter Pin
12 - Washer
13 - Cotter Pin
14 - Pin, pivot
15 - Link
16 - Washer
17 - Cotter Pin
18 - Switch
19 - Jumper Wire Ass'y
20 - Terminal Block
21 - Screw
22 - Retainer
23 - Screw
24 - Detent Pin
25 - Spring
26 - Bushing
27 - Washer
28 - Cam
29 - Insert
30 - Plate
31 - Screw
32 - Nut
33 - Disconnect
34 - Plate
35 - Bushing
36 - Lever
37 - Spring
38 - Button Ass'y
39 - Spring
40 - Washer
41 - Nut
42 - Detent Pin
43 - Spring
44 - Screw
45 - Washer
46 - Cover
47 - Handle
48 - Connector
49 - Screw
50 - Plate
51 - Screw
52 - Retainer
53 - Cover
54 - Switch Ass'y
55 - Jumper Wire
56 - Retainer
57 - Screw
58 - Harness
59 - Clip
60 - Screw
61 - "D" Washer
62 - Harness
63 - Screw Ass'y
64 - Washer
65 - Nut
66 - Cable Ass'y
67 - Switch and Plate
68 - Cable
69 - Screw
70 - Washer
71 - Switch
72 - Screw
73 - Lockwasher
74 - Nut
75 - Cable
76 - Clip
77 - Screw
78 - "D" Washer



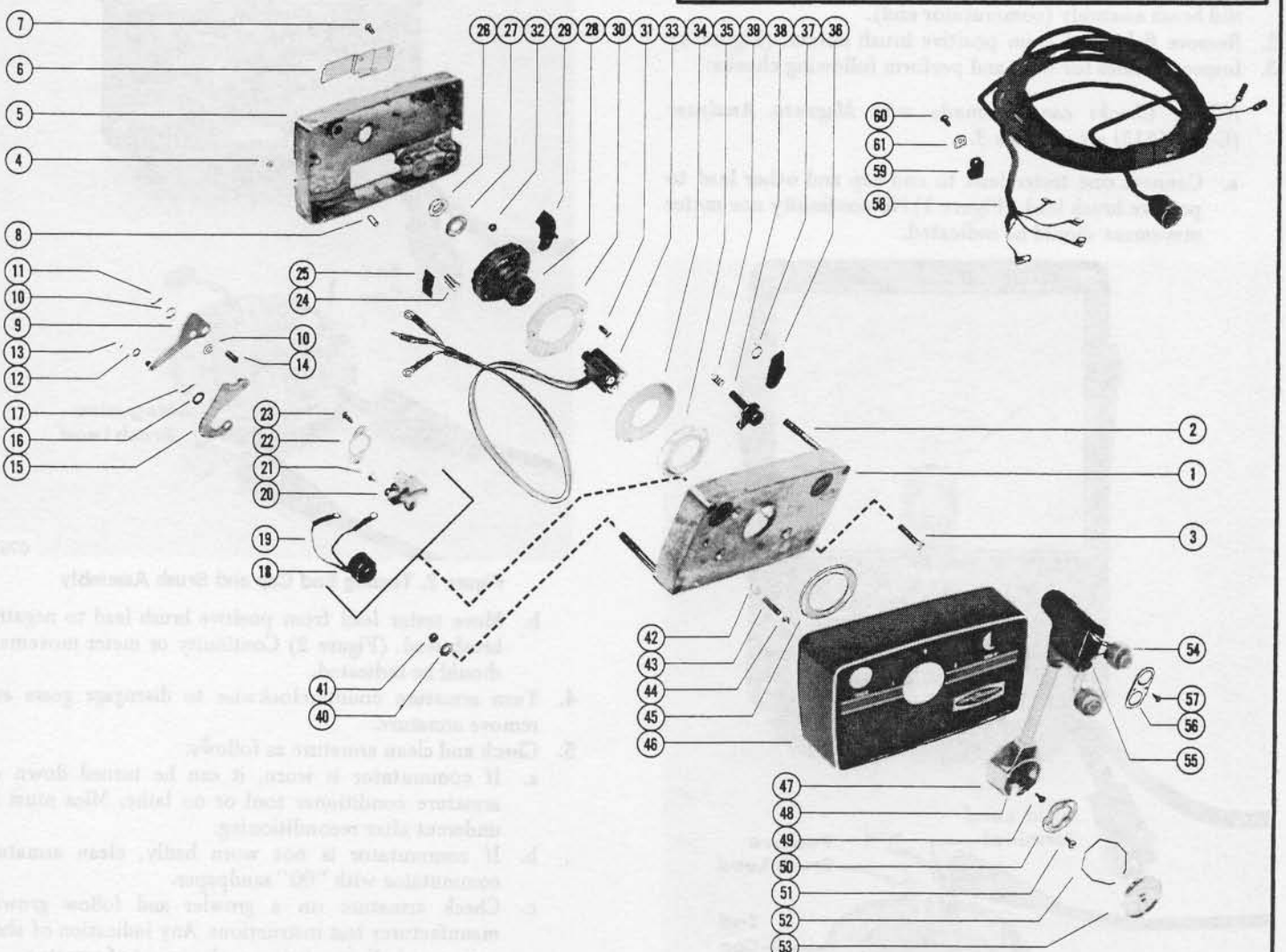


Figure 6. Deluxe MerControl

II-TR and II-TRS SHIFT MOTOR REMOVAL

1. Disconnect battery cables from battery.
2. Remove dust cover.
3. Disconnect green, orange and blue shift control harness leads and harness clamp from mounting bracket.
4. Remove reverse lock valve assembly and place assembly aside. DO NOT disconnect hydraulic lines from reverse lock.
5. Remove shift motor and mounting bracket from transmission.
6. Remove mounting bracket from shift motor.

DISASSEMBLY and TESTING

NOTE: Shift motor part number is located on motor housing.

WARNING: DO NOT remove, alter or attempt to remove or alter, in any manner, any wiring on the shift actuator or shift motor, other than covered in following repair procedure.

1. Remove 2 thru bolts with ground lead and remove end cap and brush assembly (commutator end).
2. Remove field lead from positive brush holder. (Figure 1)
3. Inspect brushes for wear and perform following checks:

   NOTE: Checks can be made with Magneto Analyzer (C-91-25213) set on Scale 3.

   a. Connect one tester lead to end cap and other lead to positive brush lead. (Figure 1) No continuity nor meter movement should be indicated.

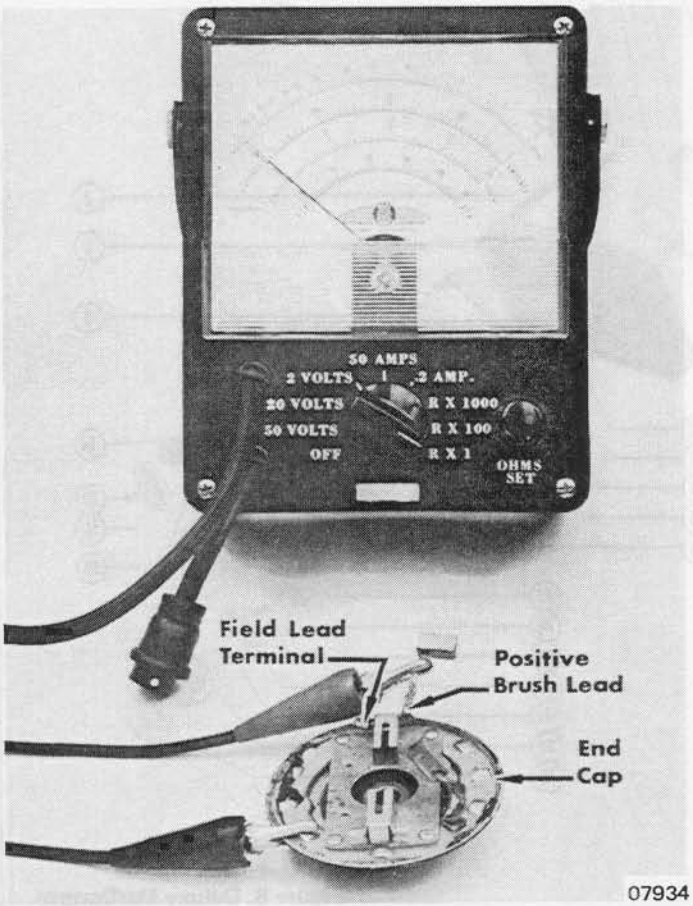


Figure 1. Testing End Cap and Brush Assembly

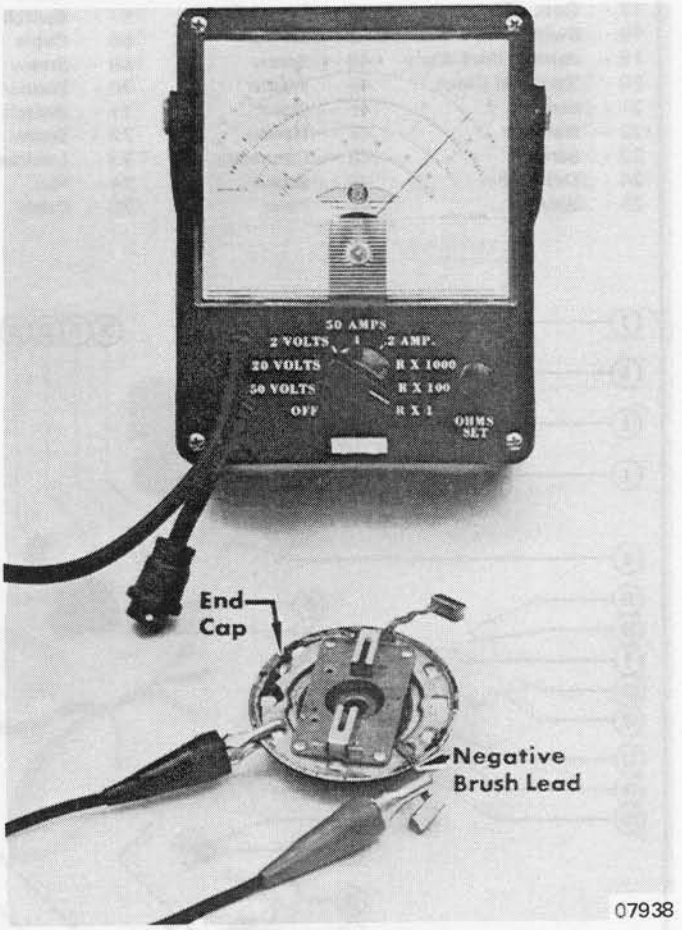


Figure 2. Testing End Cap and Brush Assembly

   b. Move tester lead from positive brush lead to negative brush lead. (Figure 2) Continuity or meter movement should be indicated.
4. Turn armature counterclockwise to disengage gears and remove armature.
5. Check and clean armature as follows:
   a. If commutator is worn, it can be turned down on armature conditioner tool or on lathe. Mica must be undercut after reconditioning.
   b. If commutator is not worn badly, clean armature commutator with "00" sandpaper.
   c. Check armature on a growler and follow growler manufacturer test instructions. Any indication of short or open windings requires replacement of armature.
6. Remove switch plate cover and unsolder yellow and green field winding leads from their respective terminals. (Figure 3 or 4)
7. Feed field winding leads thru end plate rubber grommet and remove field and frame assembly.

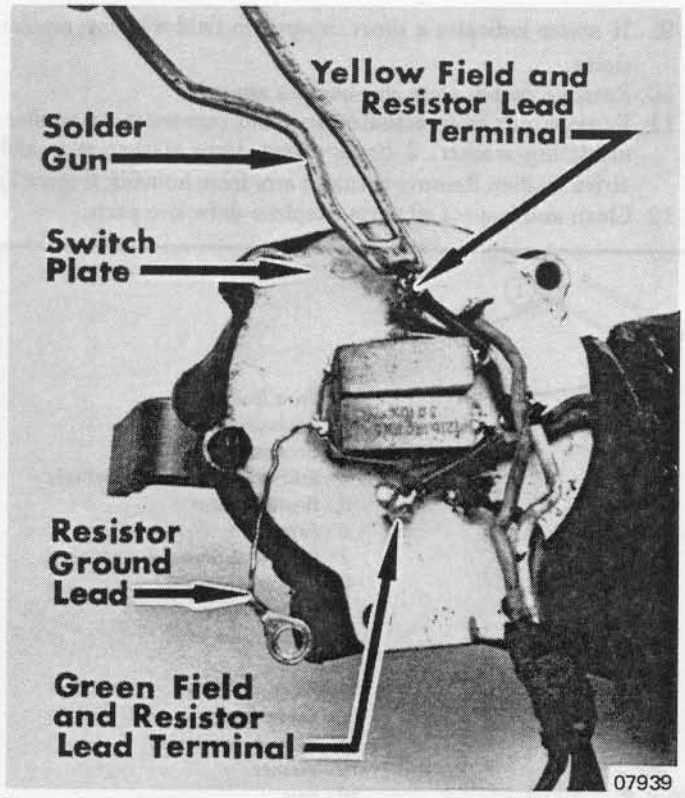


Figure 3. Switch Plate and Field Winding Leads for Shift Motor B-62845 (MerCruiser II-TR and II-TRS) and B-70260 (MerCruiser I)

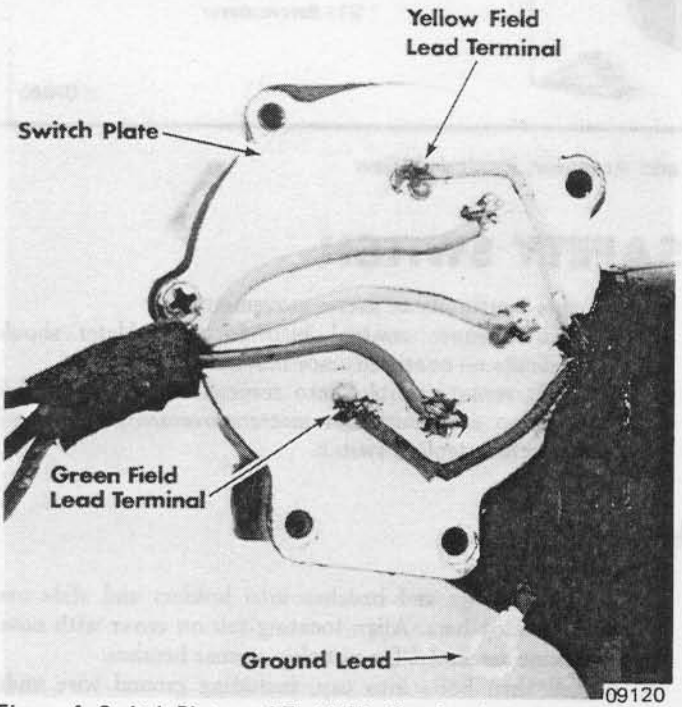


Figure 4. Switch Plate and Field Winding Leads for Shift Motor B-69392 (MerCruiser II-TR and II-TRS) and B-71919 (MerCruiser I)

8. Check field windings as follows:

NOTE: Checks can be made with Magneto Analyzer (C-91-25213) set on Scale 3.

a. Open - Connect one tester lead to commutator end of field windings and other tester lead to field yellow lead. (Figure 5) Continuity or meter movement should be indicated. Move tester lead from field yellow lead to

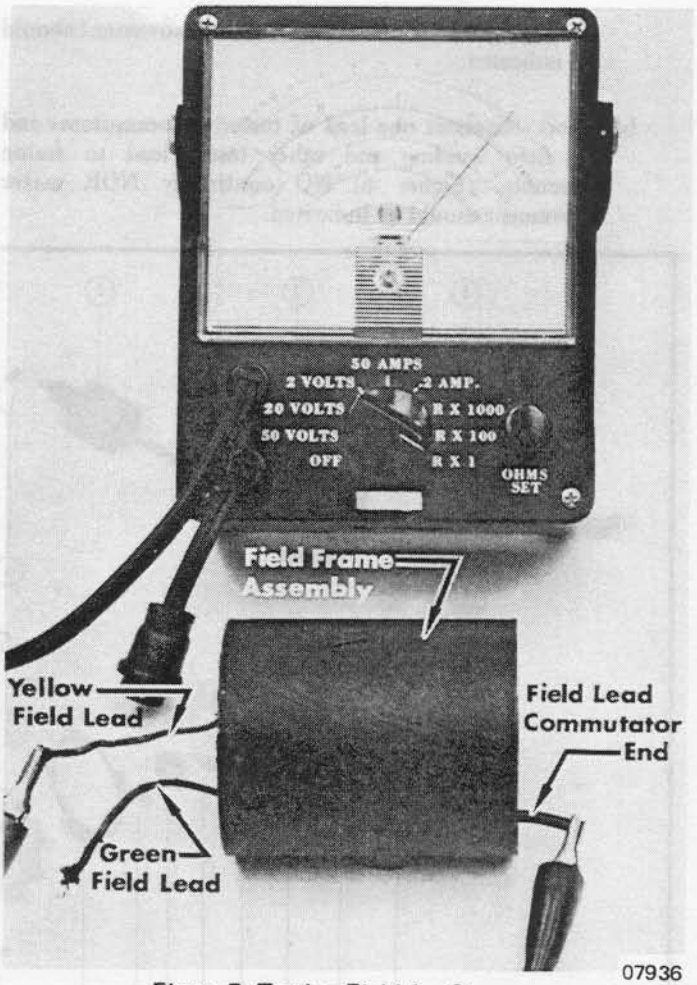


Figure 5. Testing Field for Open

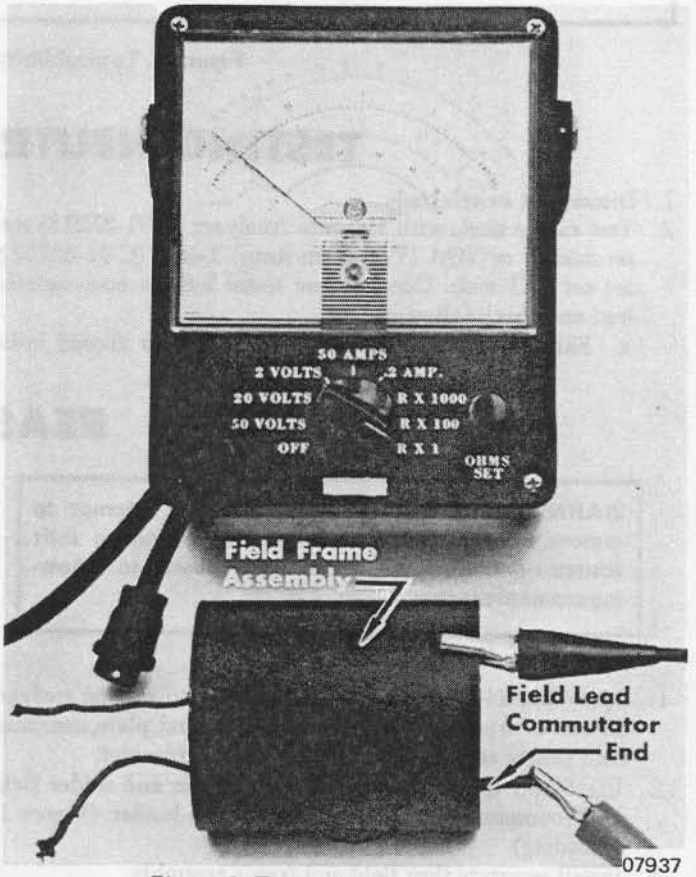


Figure 6. Testing Field for Short

field green lead. Continuity or meter movement should be indicated.

b. Short - Connect one lead of tester to commutator end of field winding and other tester lead to frame assembly. (Figure 6) NO continuity NOR meter movement should be indicated.

9. If meter indicates a short or open in field winding, replace fields.
10. Remove switch plate and harness assembly.
11. Remove nut from actuator arm and remove metal washer, insulating washer, 2 brass plates, large washer, gear and drive washer. Remove actuator arm from housing. (Figure 7)
12. Clean and inspect all parts. Replace defective parts.

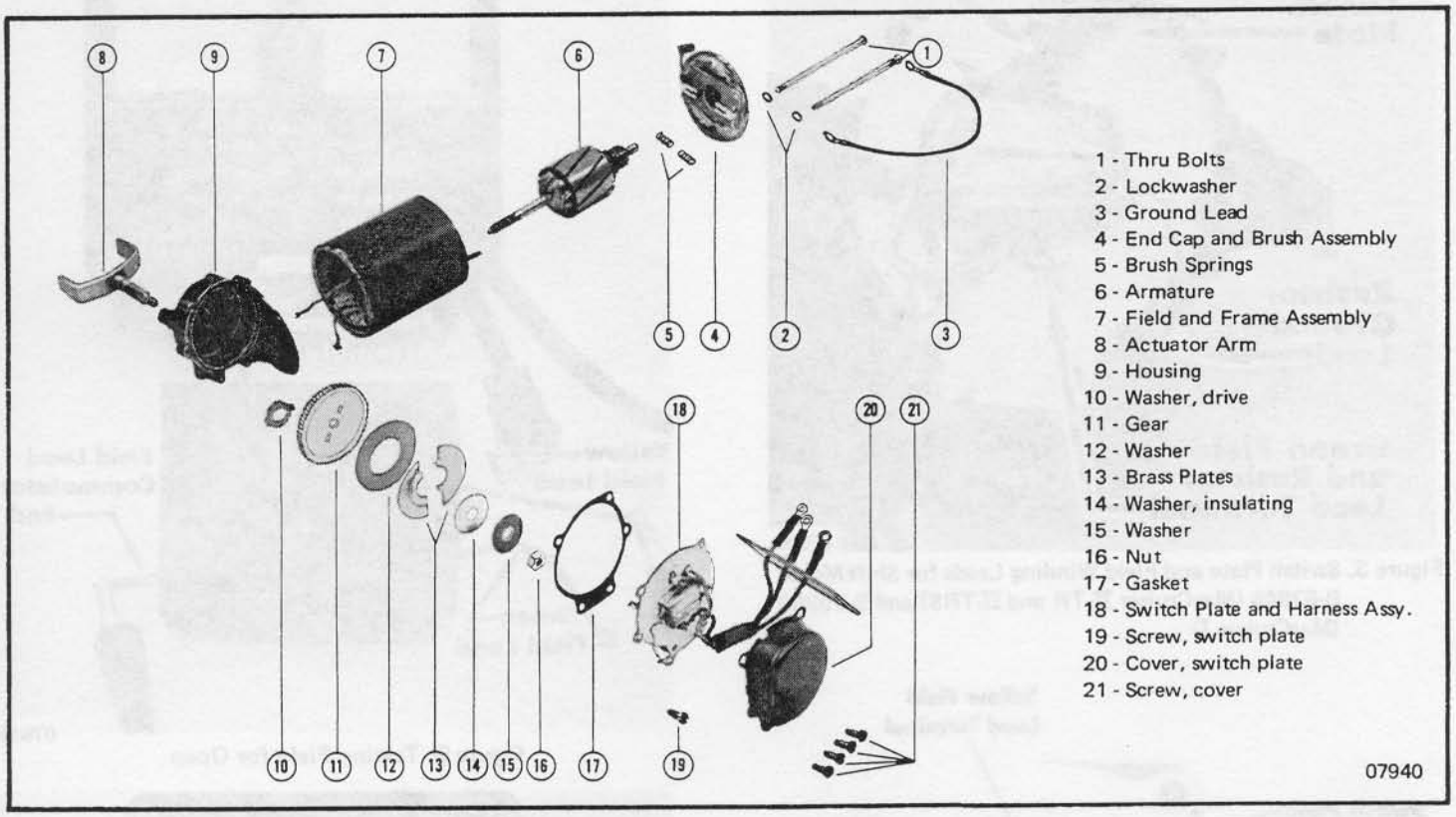


Figure 7. Typical Shift Motor and Actuator, Exploded View

TESTING NEUTRAL SAFETY SWITCH

1. Disconnect switch leads.
2. Test can be made with Magneto Analyzer (C-91-25213) set on Scale 3 or VOA (Volt-Ohm-Amp) Tester (C-91-52751) set on RXI scale. Connect one tester lead to each switch lead and check following.
   a. Shift remote control into neutral. Meter should indicate continuity or meter movement.
   b. Shift remote control into forward. Meter should indicate no continuity nor meter movement.
   c. Shift remote control into reverse. Meter should indicate no continuity nor meter movement. If switch is defective, replace switch.

REASSEMBLY

WARNING: DO NOT remove, alter or attempt to remove or alter, in any manner, any wiring on shift actuator or shift motor, other than covered in following repair procedure.

1. Apply Liquid Neoprene (C-92-25711-1) to mating surface on end of frame assembly, install onto end plate, inserting field yellow and green leads thru rubber grommet.
2. Use 50-50 tin-lead alloy resin core solder and solder field lead (commutator end) to positive brush holder. (Figure 1, preceding)
3. Install armature thru field and frame assembly.
4. Apply Liquid Neoprene to upper edge of frame assembly, depress springs and brushes into holders and slide over commutator bars. Align locating tab on cover with notch on frame assembly. Do not chip or mar brushes.
5. Install thru bolts into cap, including ground wire under one bolt.
6. Adjust armature preload as follows:
   a. Shift actuator gear must be removed to adjust armature preload.
   b. Turn preload adjusting screw (Figure 8) counterclockwise one full turn.
   c. Connect shift motor ground wire (located under thru bolt) to negative terminal of battery. Battery should not be more than 12 volts.

d. Connect positive battery terminal, with ammeter in series, to either field lead. (Figure 8) This will allow motor to run.

NOTE: If field leads are soldered to switch plate terminals, positive battery lead may be attached to proper terminal.

e. With motor running, observe ammeter and turn adjusting screw clockwise until current draw begins to rise, then turn screw counterclockwise ¼ to 3/8-turn.

f. Apply Liquid Neoprene (C-92-25711-1) to head of adjusting screw so that screw does not move after adjustment.

7. Solder field leads to switch plate as shown in Figure 3 or 4, preceding. Use 50-50 tin-lead alloy resin core solder. Be sure that resistor leads also are attached to switch plate field lead terminals. (Figure 3 only)
8. Coat all switch terminals with Liquid Neoprene.
9. Install actuator arm into housing. Install drive washer (tabs toward gear), gear (lettered side down), large washer, 2 brass plates (tabs into slots in gear), insulating washer (tabs into slots in gear), metal washer and nut, as shown in Figure 7. Tighten nut securely.
10. Lubricate worm gear and driven gear with Multipurpose Lubricant (C-92-63250). Lubricate brass switch plates with a VERY LIGHT coat of Multipurpose.
11. Use a new gasket under switch plate. Apply Liquid Neoprene to mating surface of switch plate cover and install cover. Install resistor ground lead under one screw.

CAUTION: Shift motor and actuator must be watertight. Make sure that all mating surfaces are sealed with Liquid Neoprene (C-92-25711-1).

Figure 8. Adjusting Armature Preload

INSTALLATION

1. Turn transmission shift lever counterclockwise against its stop. This is reverse position of transmission.
2. Shift the shift motor into reverse position by connecting motor black ground lead to negative battery terminal and motor harness blue lead to positive battery terminal.

CAUTION: DO NOT remove battery leads until motor completes its shift cycle.

Remove leads from battery.

3. Attach mounting bracket to shift motor.
4. Install reverse lock assembly.
5. Apply a coat of Multipurpose Lubricant (C-92-63250) on plunger end of reverse lock assembly. (Figure 9)
6. Use Multipurpose to completely fill space between end of motor housing and fork of output shaft. Also fill space between cam for reverse lock valve and cover on transmission. (Figure 9)
7. Insert shift motor actuator arms into slots on transmission shift lever and mount shift motor assembly to transmission.
8. Install shift motor harness and control box harness on junction block, matching colors.
9. Attach control harness clamp to motor mounting bracket.
10. Install dust cover.

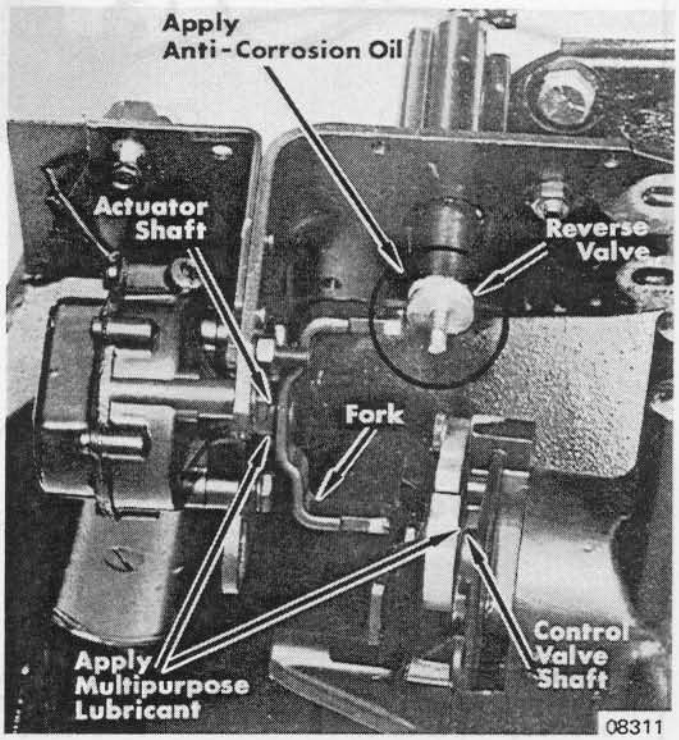


Figure 9. Lubricant Application

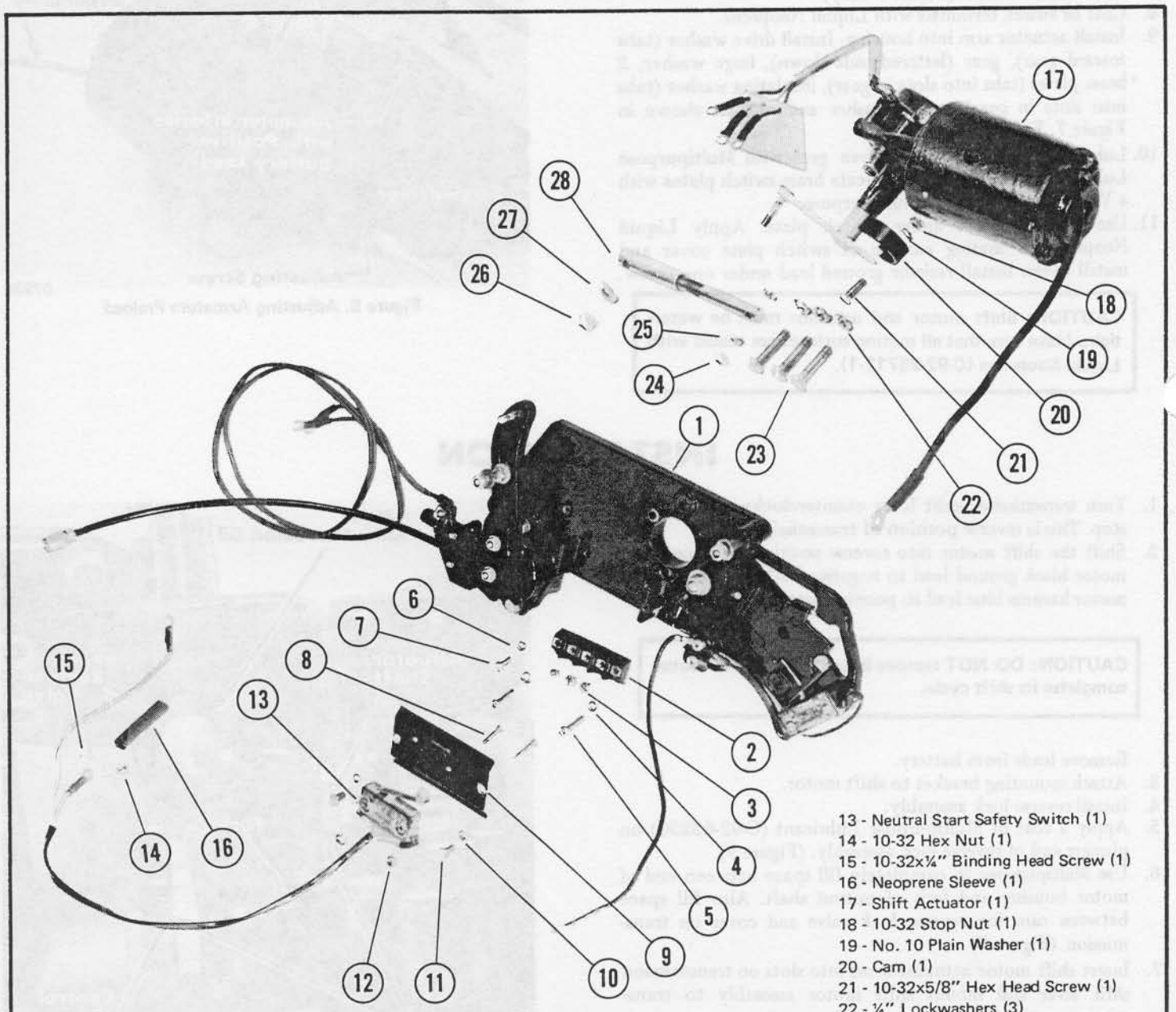
120-140-165-888-225S and 233 SHIFT MOTOR

REMOVAL

1. Remove shift link and cam from shift actuator. (Figure 1)
2. Remove neutral start safety switch and shield as an assembly.
3. Disconnect actuator 3 wires from terminal block.
4. Disconnect actuator ground wire from shift cutout switch terminal block.
5. Remove 3 hex head screws, which hold actuator to shift bracket assembly, and remove actuator assembly.

DISASSEMBLY, TESTING and REASSEMBLY

Refer to "MerCruiser II-TR and II-TRS Shift Motor - Disassembly, Testing and Reassembly" (see "Index").



1 - Shift Bracket Assembly
2 - Terminal Block (1)
3 - Binding Head Screw (3)
4 - No. 10 Lockwashers (2)
5 - 10-32x7/8" Phillips Screws (2)
6 - No. 10 Lockwasher (1)
7 - 10-32x½" Hex Head Screw (1)
8 - 6-32x15/16" Hex Head Screw (2)
9 - Shield (1)
10 - No. 10 Lockwasher (2)
11 - 10-32x3/8" Hex Head Screws (2)
12 - 6-32 Stop Nuts (2)
13 - Neutral Start Safety Switch (1)
14 - 10-32 Hex Nut (1)
15 - 10-32x¼" Binding Head Screw (1)
16 - Neoprene Sleeve (1)
17 - Shift Actuator (1)
18 - 10-32 Stop Nut (1)
19 - No. 10 Plain Washer (1)
20 - Cam (1)
21 - 10-32x5/8" Hex Head Screw (1)
22 - ¼" Lockwashers (3)
23 - ¼-28x1-1/8" Hex Head Screws (3)
24 - 10-32 Stop Nut (1)
25 - No. 10 Brass Flat Washer (2)
26 - Stop Nut (1)
27 - Flat Washer (1)
28 - Shift Link Assembly (1)

Figure 1. Parts Identification

SHIFT MOTOR and RELATED PARTS INSTALLATION

CAUTION: Battery MUST BE disconnected before starting installation.

1. Install shift actuator to shift bracket with three ¼-28 x 1-1/8" hex head screws and three ¼" lockwashers. (Figure 2) Use Loctite (supplied in kit) on threads of screws. Torque screws to 55-60 in. lbs. (63-69kg-cm).

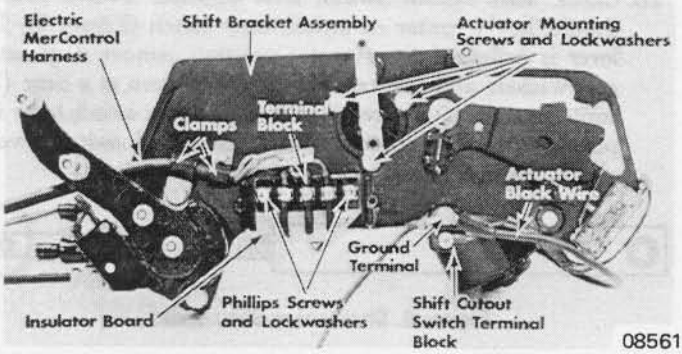


Figure 2. Installing Actuator and Wires

2. Route actuator harness between actuator and shift plate as shown in Figure 3.

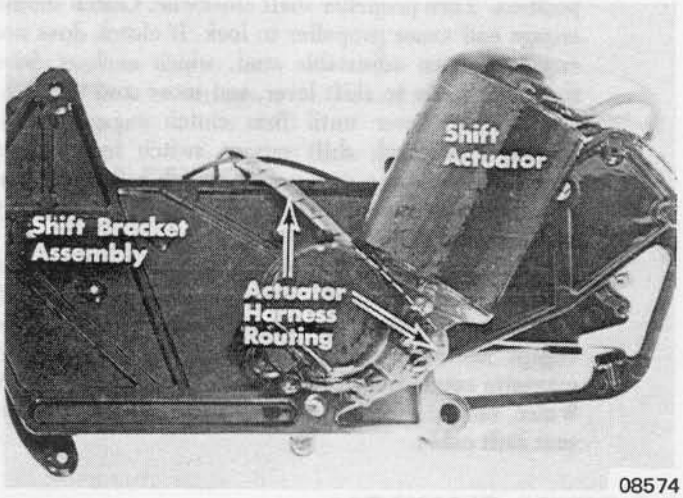


Figure 3. Actuator Harness Routing

3. Install actuator harness insulator board with terminal block to shift bracket. (Figure 2) Use two 10-32 x 7/8" phillips screws and 2 No. 10 lockwashers.
4. Install electric MerControl harness and shift actuator harness to terminal block, matching colors. (Figure 2) Use three 8-32 x ¼" binding head screws.
5. Fasten control harness to shift plate with clamp molded to harness and one 10-32 x ½" hex head screw and one No. 10 lockwasher. (Figure 2) Also fasten control harness to reverse lock assembly with clamp supplied in kit. (Figure 2) Retorque reverse lock mounting screw to 10-12 ft. lbs. (1.4-1.7mkg).
6. Connect actuator black wire to ground terminal on shift cutout switch terminal block. (Figure 2)
7. Install neutral start safety switch cam to shift actuator. The 10-32 x 5/8" hex head screw MUST be installed from top, thru shift actuator arm, then thru cam. (Figure 2) Now install one No. 10 plain washer and one 10-32 stop nut.

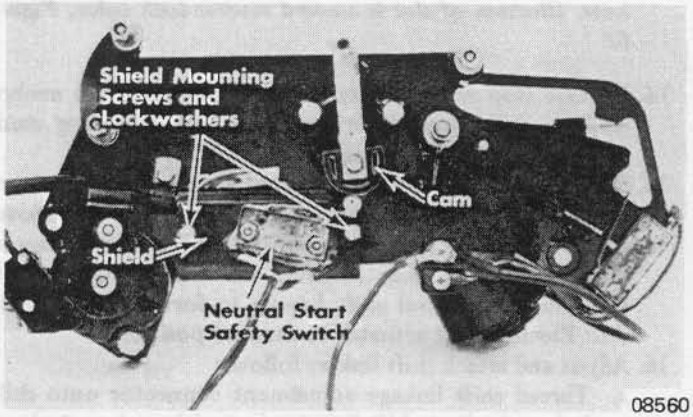


Figure 4. Safety Switch, Cam and Shield Installation

8. If not already completed, install neutral start safety switch on terminal block shield. The two 6-32 x 15/16" hex head screws MUST be installed from bottom of shield with two 6-32 stop nuts on top. (Figure 4)
9. Use two 10-32 x 3/8" hex head screws and two No. 10 lockwashers to install terminal block shield and safety switch assembly to shift plate. (Figure 4)
10. Remove small yellow engine harness wire from starter slave solenoid (located on engine) and install yellow (with black stripe) wire from neutral start safety switch to this solenoid terminal. (Figure 5)
11. Connect yellow engine harness wire (removed from solenoid) to yellow wire from neutral start safety switch. Use one 10-32 x ¼" binding head screw, one 10-32 hex nut (with lockwasher attached) and neoprene sleeve. (Figure 5)

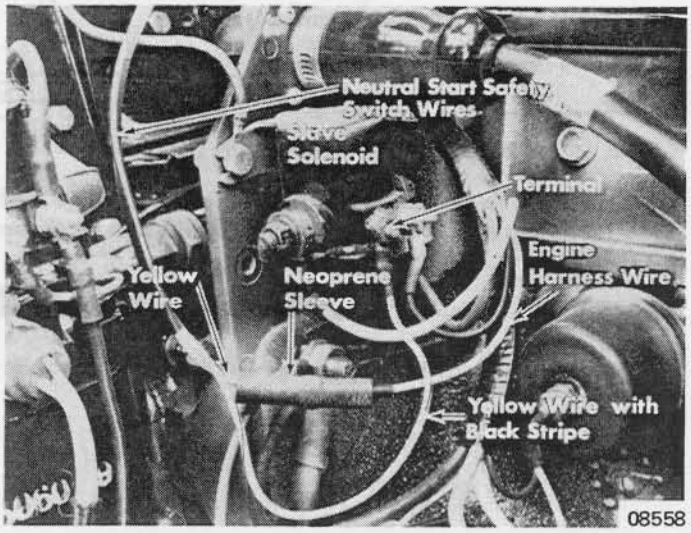


Figure 5. Neutral Start Safety Switch Wire Connection

12. Install drive unit cable to shift bracket. (Figure 6)
13. Connect battery and turn ignition key switch to "Run" position to allow Electric Shift to operate.

CAUTION: DO NOT leave ignition switch in "Run" position for long periods of time (without engine running), or ignition points may be damaged.

NOTE: Before beginning shift adjustment, the adjustable stud (on shift lever) must be to bottom of slot in shift lever. (Bottom of slot is toward reverse lock valve, Figure 6)

14. Remove stop nut and flat washer from shift link anchor stud on shift lever. Lubricate shift link attaching studs with Multipurpose Lubricant (C-92-63250).
15. Shift drive unit into full forward by moving shift lever toward Electric Shift actuator as far as it will move. WHILE shifting, turn propeller shaft counterclockwise until shaft stops, thus ensuring full clutch engagement. Move remote control shift handle to forward position to shift Electric Shift actuator to forward position.
16. Adjust and attach shift link as follows:
    a. Thread shift linkage adjustment connector onto shift link and adjust shift link to align with anchor studs on shift lever and Electric Shift actuator. (Figure 6)

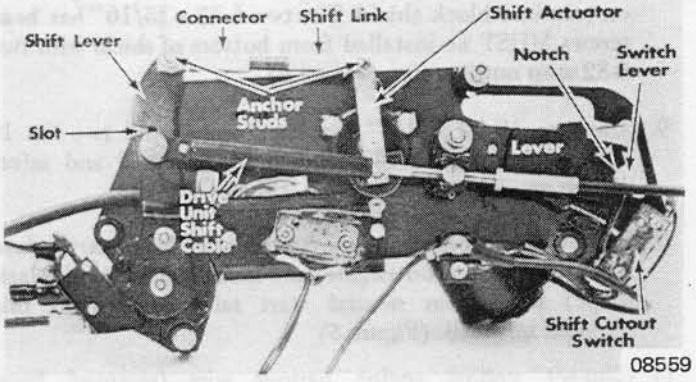


Figure 6. Drive Unit Cable and Shift Linkage Installation

    b. After shift link is aligned with anchor studs, lengthen shift link by adjusting 4 turns. (Figure 7)

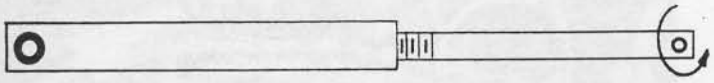


Figure 7. Lengthening Shift Link

    c. Place one No. 10 brass flat washer on Electric Shift actuator stud (Figure 6) and install shift link on anchor studs. Place second No. 10 brass flat washer on Electric Shift actuator and install one 10-32 stop nut. Place one flat washer (removed from shift lever anchor stud) on shift lever anchor stud and install stop nut.

IMPORTANT: DO NOT tighten stop nuts against shift link, as shift link must pivot freely on anchor studs.

17. Move remote control shift handle to reverse position and turn propeller shaft clockwise until shaft stops (to ensure full clutch engagement).
18. Check shift cutout switch lever position. Switch roller should be in center of switch lever notch (Figure 6). If lever is deflected from center position, remove stop nuts and washers and shorten shift link one turn at a time (3 turns maximum, Figure 8) until shift cutout switch lever is positioned with switch roller in center of switch lever notch. Install washers and stop nuts.

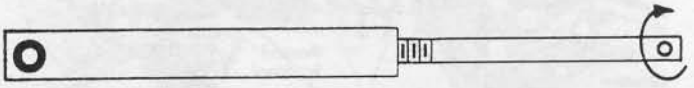


Figure 8. Shortening Shift Link

19. Perform the following check to determine if further shift adjustment is required:
    a. Out-of-Water, Engine Stopped: Check and Adjustment - Move remote control shift handle into reverse position. Turn propeller shaft clockwise. Clutch should engage and cause propeller to lock. If clutch does not engage, loosen adjustable stud, which anchors drive unit shift cable to shift lever, and move stud to top of slot in shift lever until firm clutch engagement is obtained. Recheck shift cutout switch lever. Lever must be in center position with switch roller in center of notch. Tighten adjustable anchor stud at necessary location of shift lever slot.
    b. In-the-Water, Engine Running: Check and Adjustment - With engine running, move remote control shift handle into reverse position. Reverse clutch should engage smoothly with a minimum of ratcheting. If excessive ratcheting occurs, refer to Step 19a ("Out-of-Water, etc"), immediately preceding, and adjust drive unit shift cable.

TESTING NEUTRAL SAFETY SWITCH

Refer to "MerCruiser II-TR and II-TRS Shift Motor - Testing Neutral Safety Switch". (Use "Index".)

120-thru-233 ELECTRIC SHIFT LINK and CABLE ADJUSTMENT

1. Remove shift link from shift actuator and shift lever. (Figure 1)
2. Shift drive unit into full forward by moving shift lever toward Electric Shift actuator as far as it will move. WHILE shifting, turn propeller shaft counterclockwise until shaft stops, thus ensuring full clutch engagement. Move remote control shift handle to forward position to shift Electric Shift actuator to forward position.

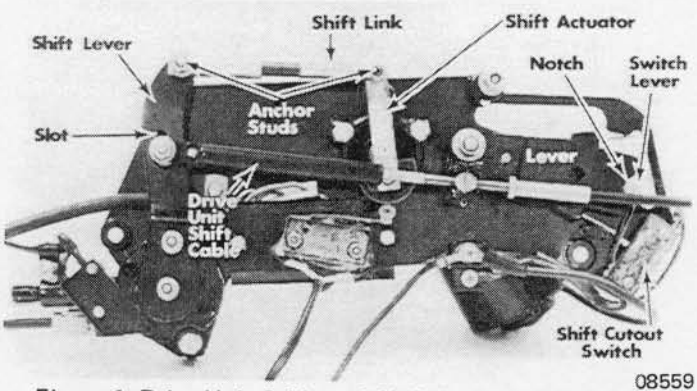


Figure 1. Drive Unit Cable and Shift Linkage Adjustment

3. Adjust shift link to align with anchor studs on shift lever and Electric Shift actuator. (Figure 1)
4. After shift link is aligned with anchor studs, lengthen shift link by adjusting 4 turns. (Figure 2)

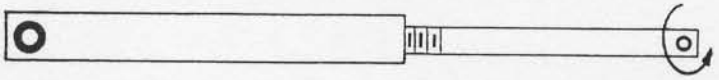


Figure 2. Lengthening Shift Link

5. Place one No. 10 brass flat washer on Electric Shift actuator stud (Figure 1) and install shift link on anchor studs. Place second No. 10 brass flat washer on electric shift actuator and install stop nut. Place one flat washer on shift lever anchor stud and install stop nut.

IMPORTANT: DO NOT tighten stop nuts against shift link, as shift link must pivot freely on anchor studs.

6. Move remote control shift handle to reverse position and turn propeller shaft clockwise until shaft stops (to ensure full clutch engagement).
7. Check shift cutout switch lever position. Switch roller should be in center of switch lever notch. (Figure 1) If lever is deflected from center position, remove stop nuts and washers and shorten shift link one turn at a time (3 turns maximum, Figure 3) until shift cutout switch lever is positioned with switch roller in center of switch lever notch. Install washers and stop nuts.

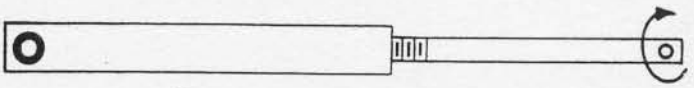


Figure 3. Shortening Shift Link

8. Perform the following check to determine if further shift adjustment is required:
   a. Out-of-Water, Engine Stopped: Check and Adjustment - Move remote control shift handle into reverse position. Turn propeller shaft clockwise. Clutch should engage and cause propeller to lock. If clutch does not engage, loosen adjustable stud, which anchors drive unit shift cable to shift lever, and move stud to top of slot in shift lever until firm clutch engagement is obtained. (Figure 1) Recheck shift cutout switch lever. Lever must be in center position with switch roller in center of notch. Tighten adjustable anchor stud at necessary location of shift lever slot.
   b. In-the-Water, Engine Running: Check and Adjustment - With engine running, move remote control shift handle into reverse position. Reverse clutch should engage smoothly with a minimum of ratcheting. If excessive ratcheting occurs, refer to Step 8a ("Out-of-Water, etc"), immediately preceding, and adjust drive unit shift cable.

SECTION 7 - ACCESSORIES

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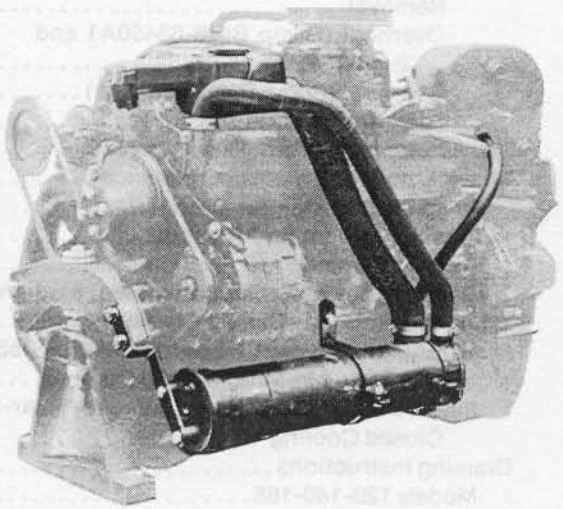
PART D - COOLING



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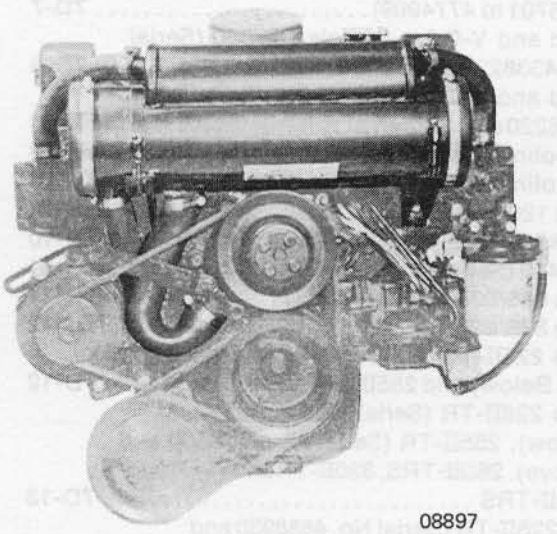

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MERCURY MARINE®

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COOLING SYSTEM
Standard Cooling System

MerCruiser engines with standard cooling systems use seawater (water in which the boat is being operated) to remove the heat given off by the engine.

See Standard Cooling System "flow diagrams", following. The seawater is pumped to the cooling system by means of an impeller type pickup pump (located in the vertical drive or belt driven at the front of engine) which picks up seawater and delivers it to the centrifugal pump (located over an opening on the front of the cylinder block). On some models, seawater may be pumped through an oil cooler before going to the circulating pump. The centrifugal pump then circulates the seawater through the block, head(s) and manifold(s), removing the heat given off by these parts as it passes.

After passing through the engine, the seawater is pumped into the exhaust elbow, where it mixes with the exhaust gases, and is expelled overboard.

A thermostatic heat control, which controls circulation of the seawater, also is incorporated into the system. It provides fast engine warmup and controlled operating temperature.

TROUBLESHOOTING

Use the following Standard Cooling System "flow diagrams" and "Engine Overheating" trouble chart in Section 10 of this Service Manual (see Sec. 10 "Index") as aids to troubleshooting Standard Cooling Systems.

Standard Cooling System Flow Diagrams

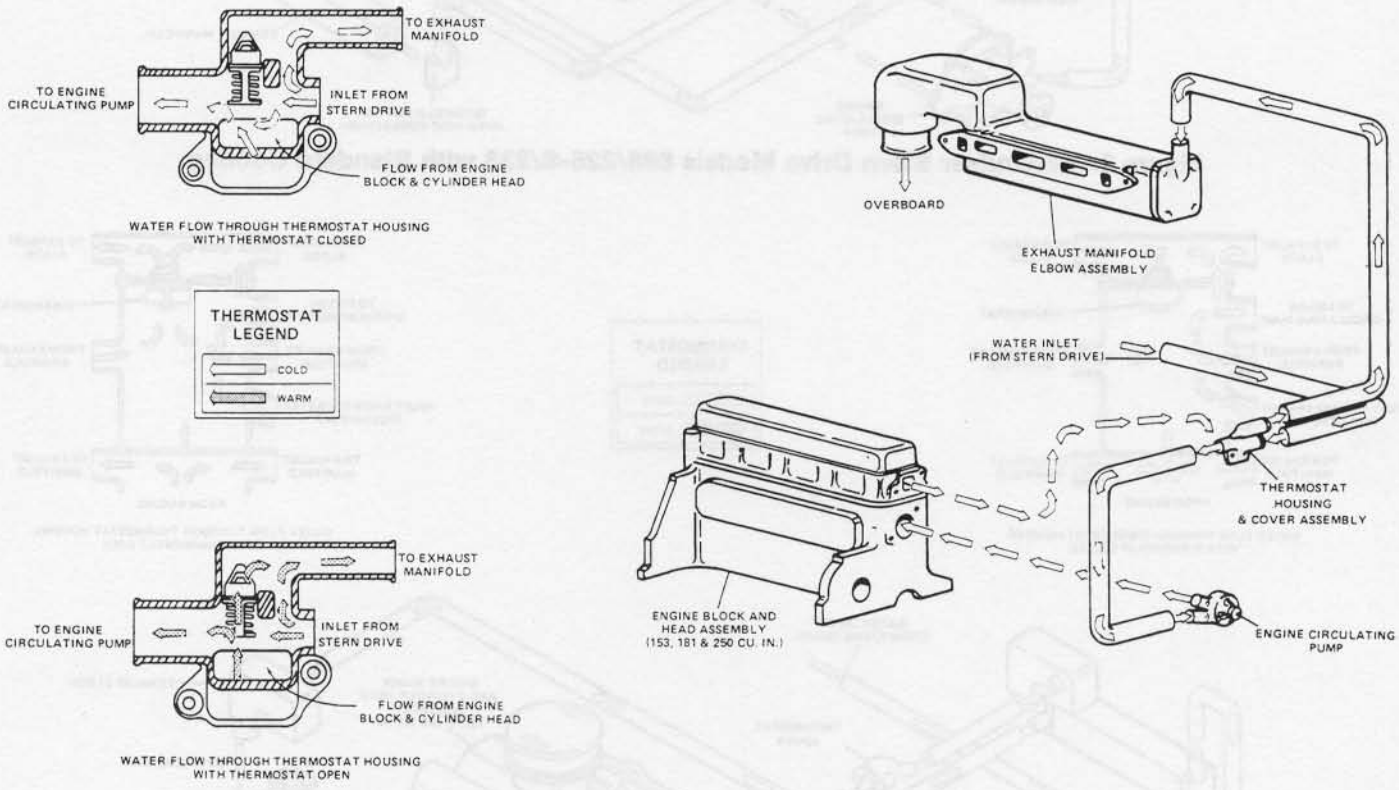


Figure 1. MerCruiser Stern Drive Models 120/140/165 with Standard Cooling

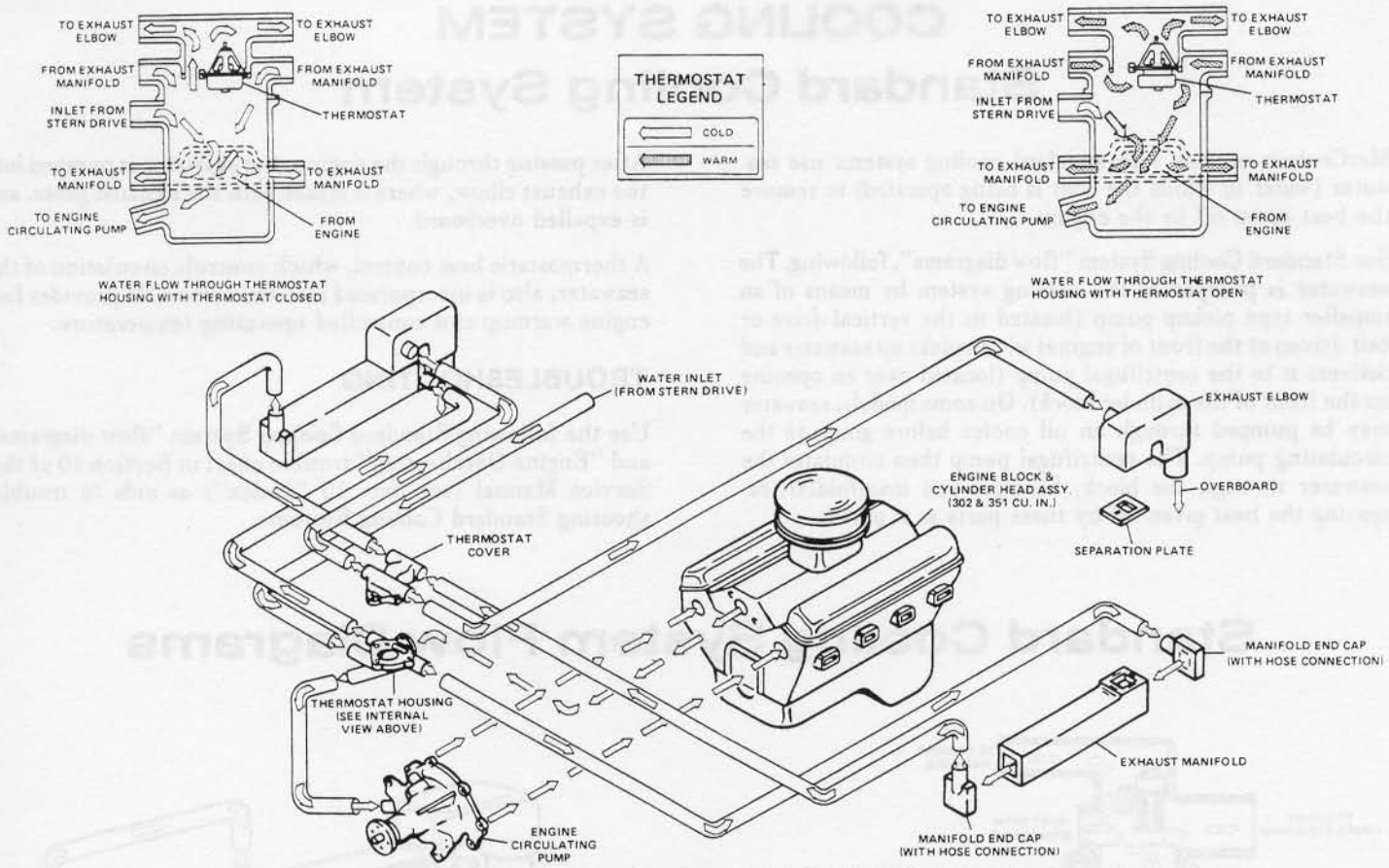


Figure 2. MerCruiser Stern Drive Models 888/225-S/233 with Standard Cooling

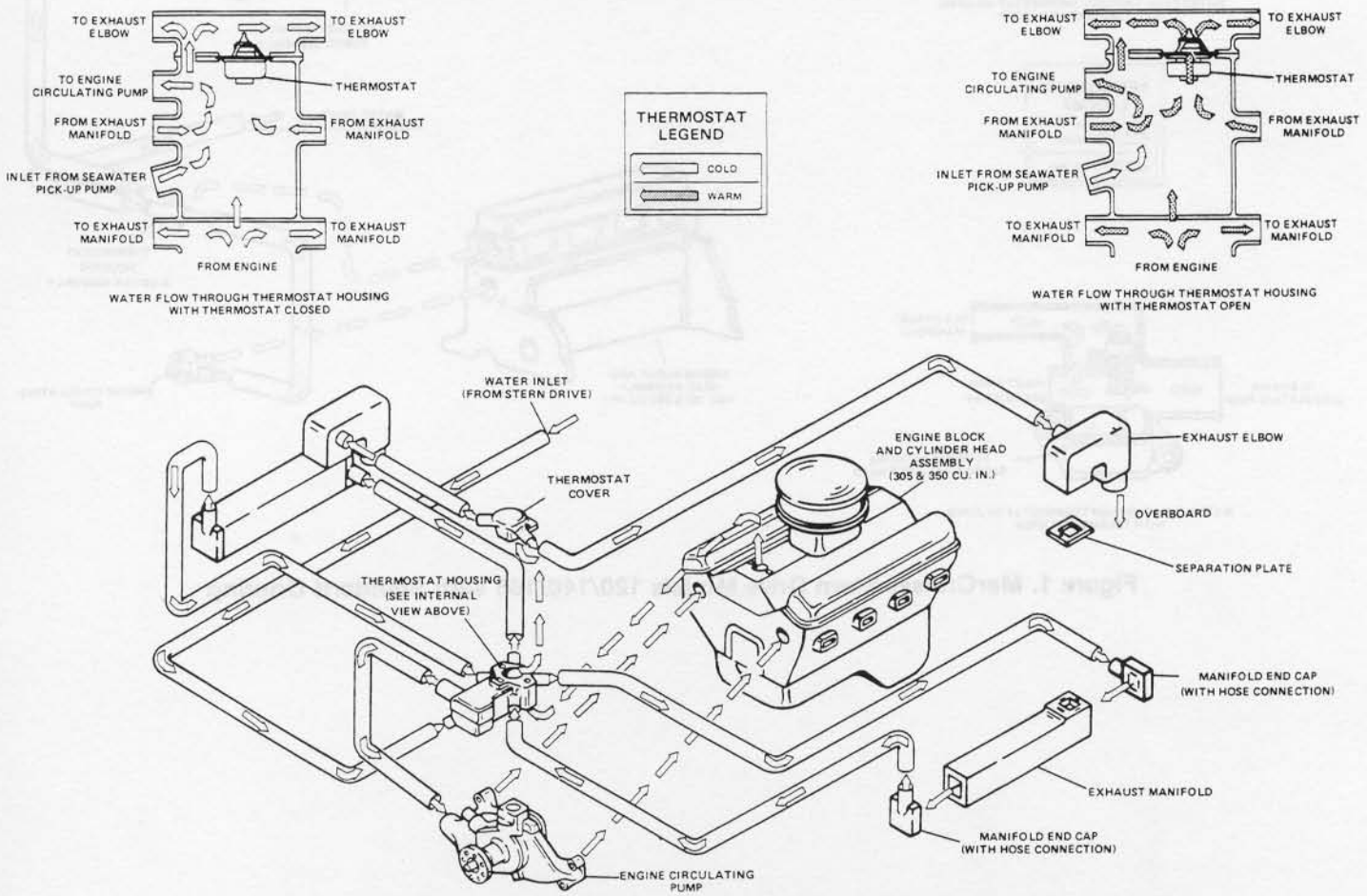


Figure 3. MerCruiser Stern Drive Models 898/228/250/260 with Standard Cooling

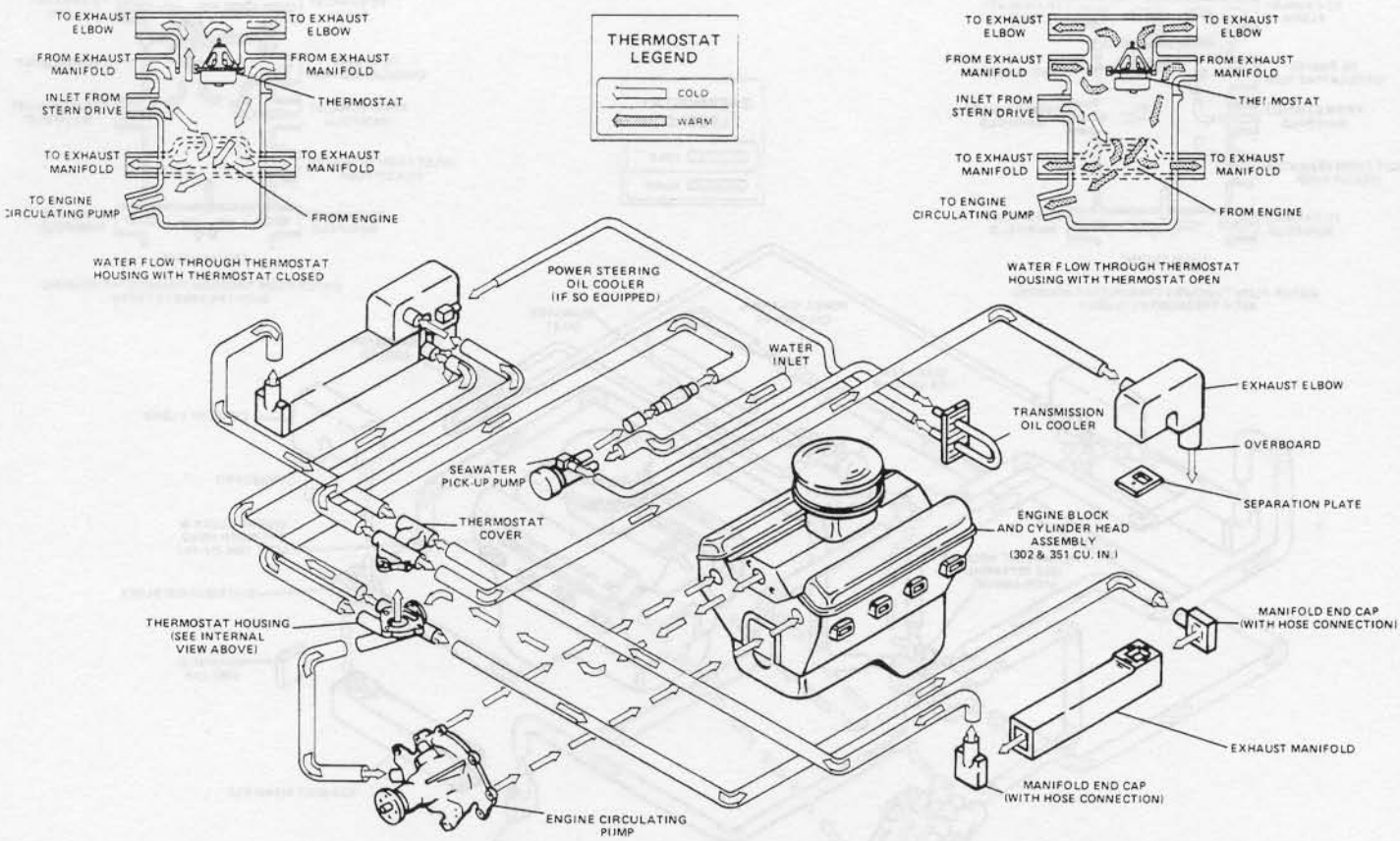


Figure 4. MerCruiser Stern Drive Models 225II-TR, 255II-TR (Serial No. 4175499 and Below) and 255II-TRS with Standard Cooling

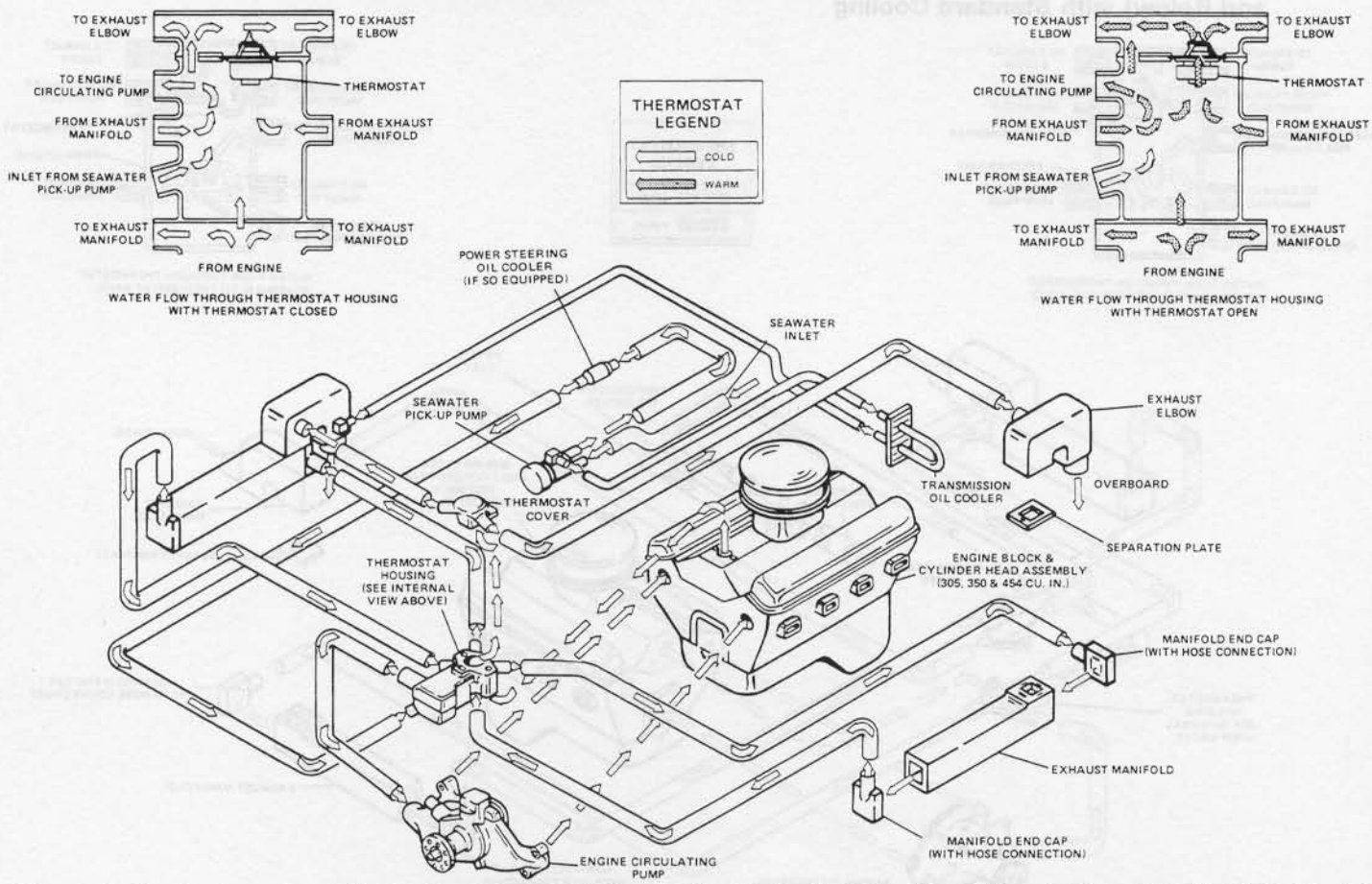


Figure 5. MerCruiser Stern Drive Models 228II-TR, 255II-TR (Serial No. 4498701 and Above), 280II-TRS (Serial No. 4499391 and Above) and 330II-TR/330II-TRS with Standard Cooling

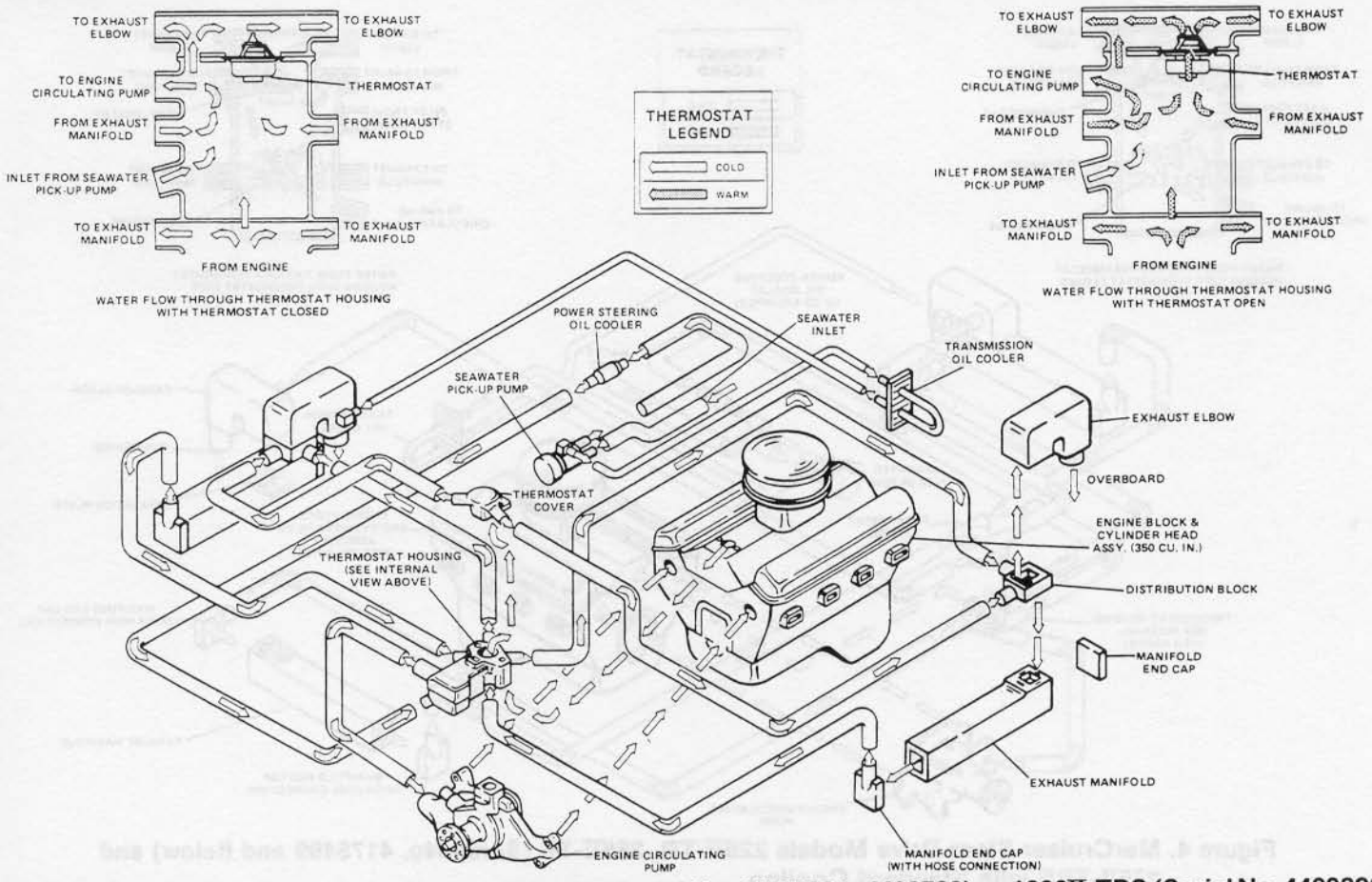


Figure 6. MerCruiser Stern Drive Models 255II-TR (Serial No. 4175500 to 4498700) and 280II-TRS (Serial No. 4499390 and Below) with Standard Cooling

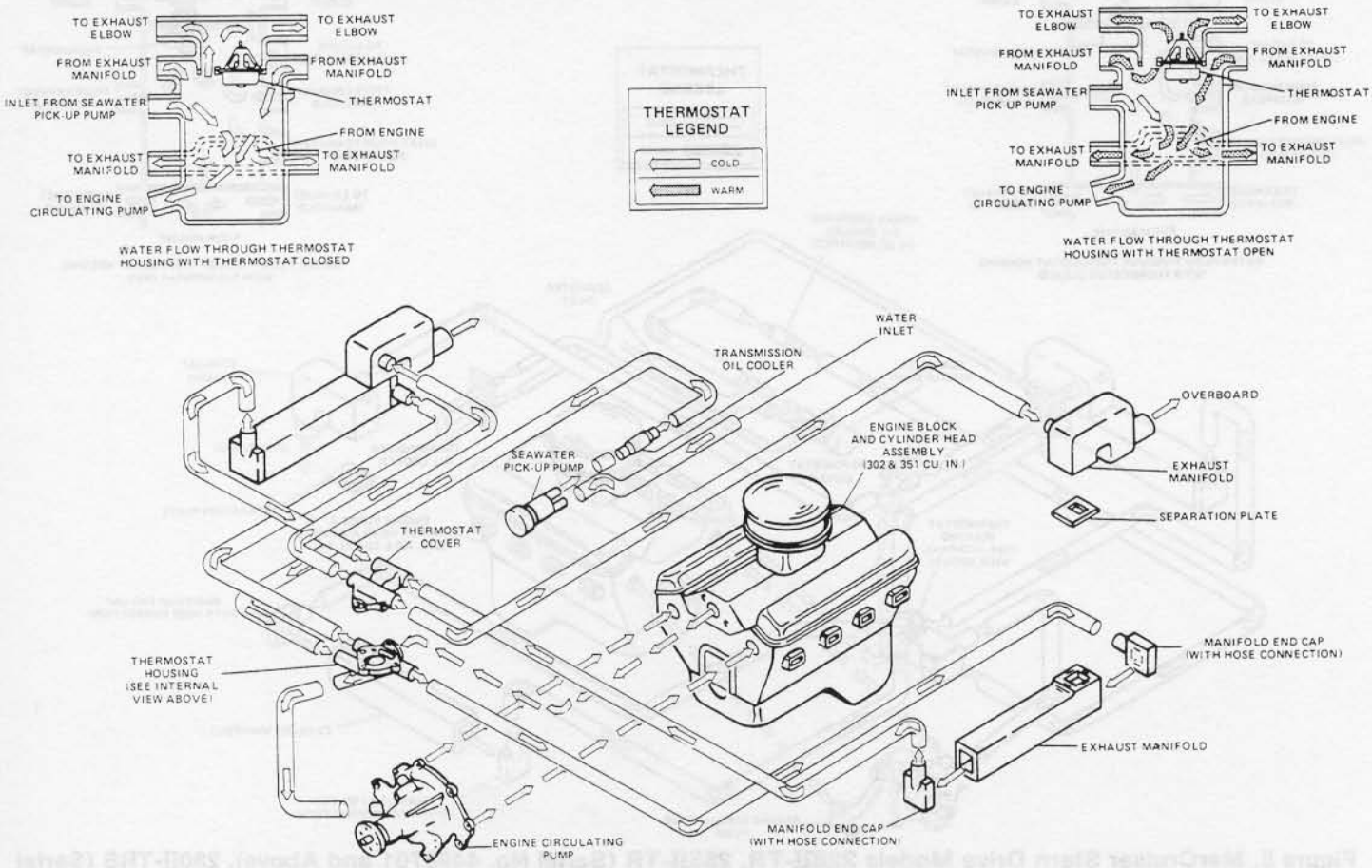


Figure 7. MerCruiser Inboard Models 225/233/255 (Serial No. 4178299 and Below) with Standard Cooling

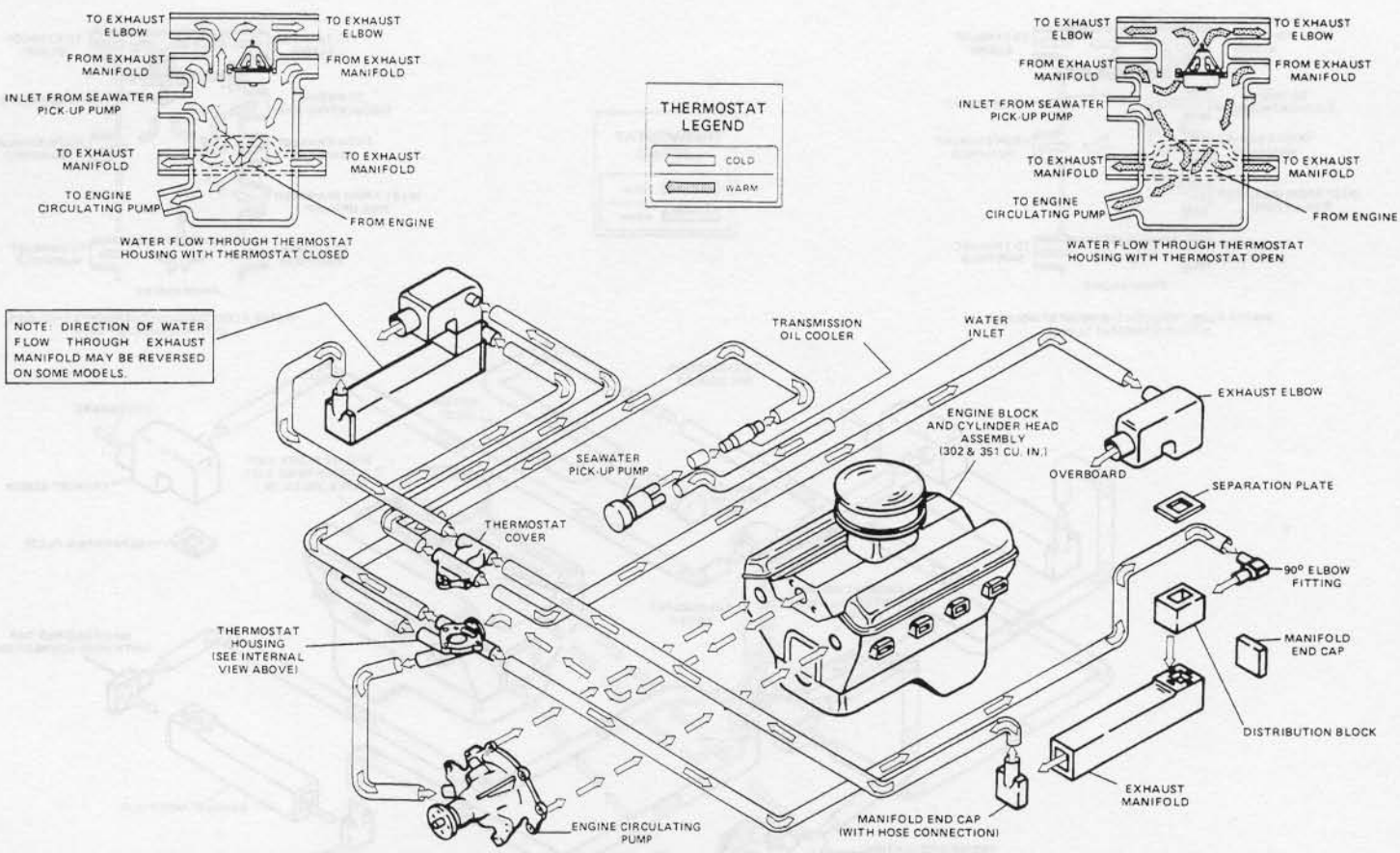


Figure 8. MerCruiser V-Drive Models 225/233/255 (Serial No. 4178299 and Below) with Reversed Manifolds and Standard Cooling

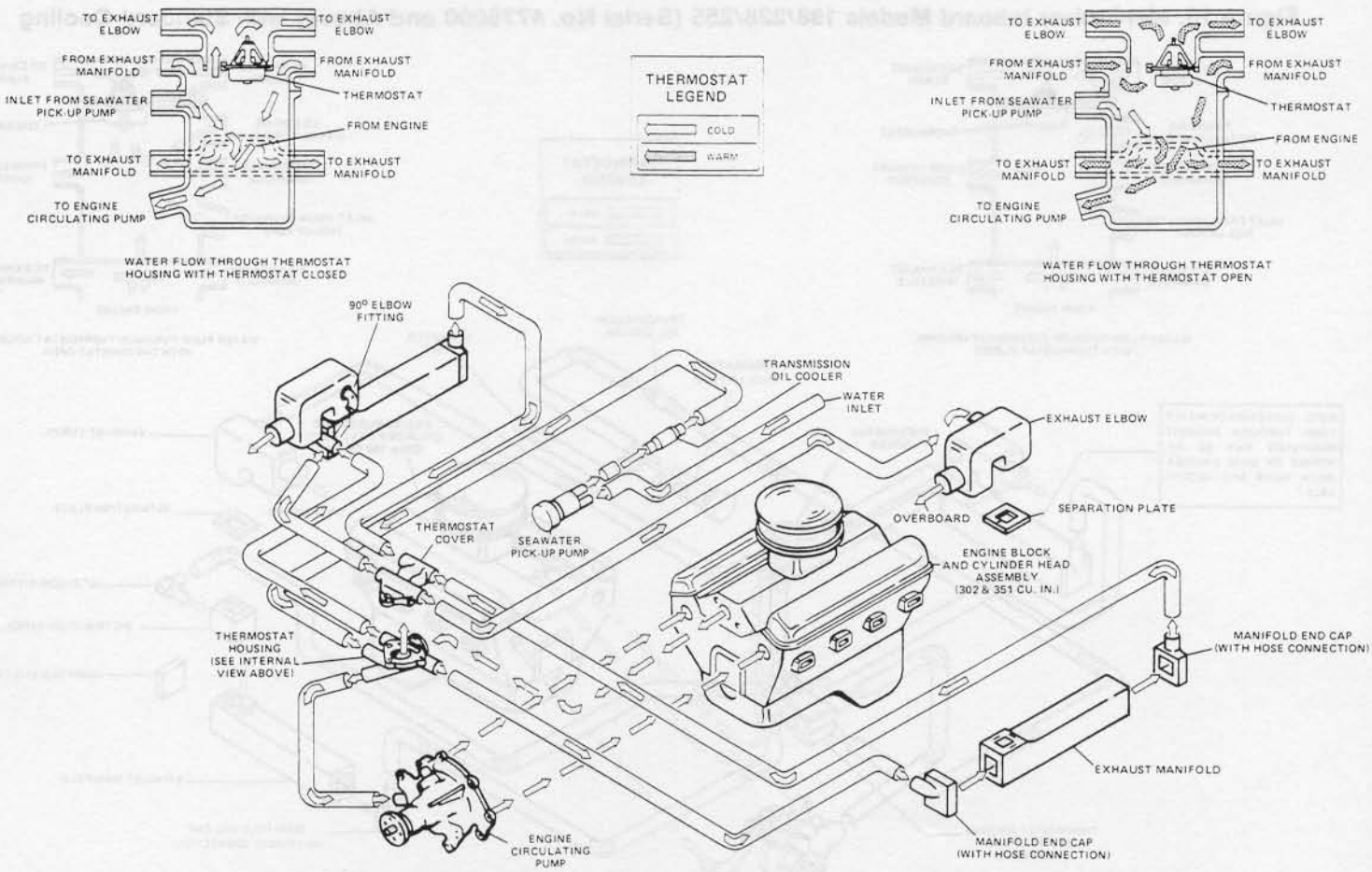


Figure 9. MerCruiser V-Drive Models 225/233/255 (Serial No. 4178299 and Below) with Reversed Elbows and Standard Cooling

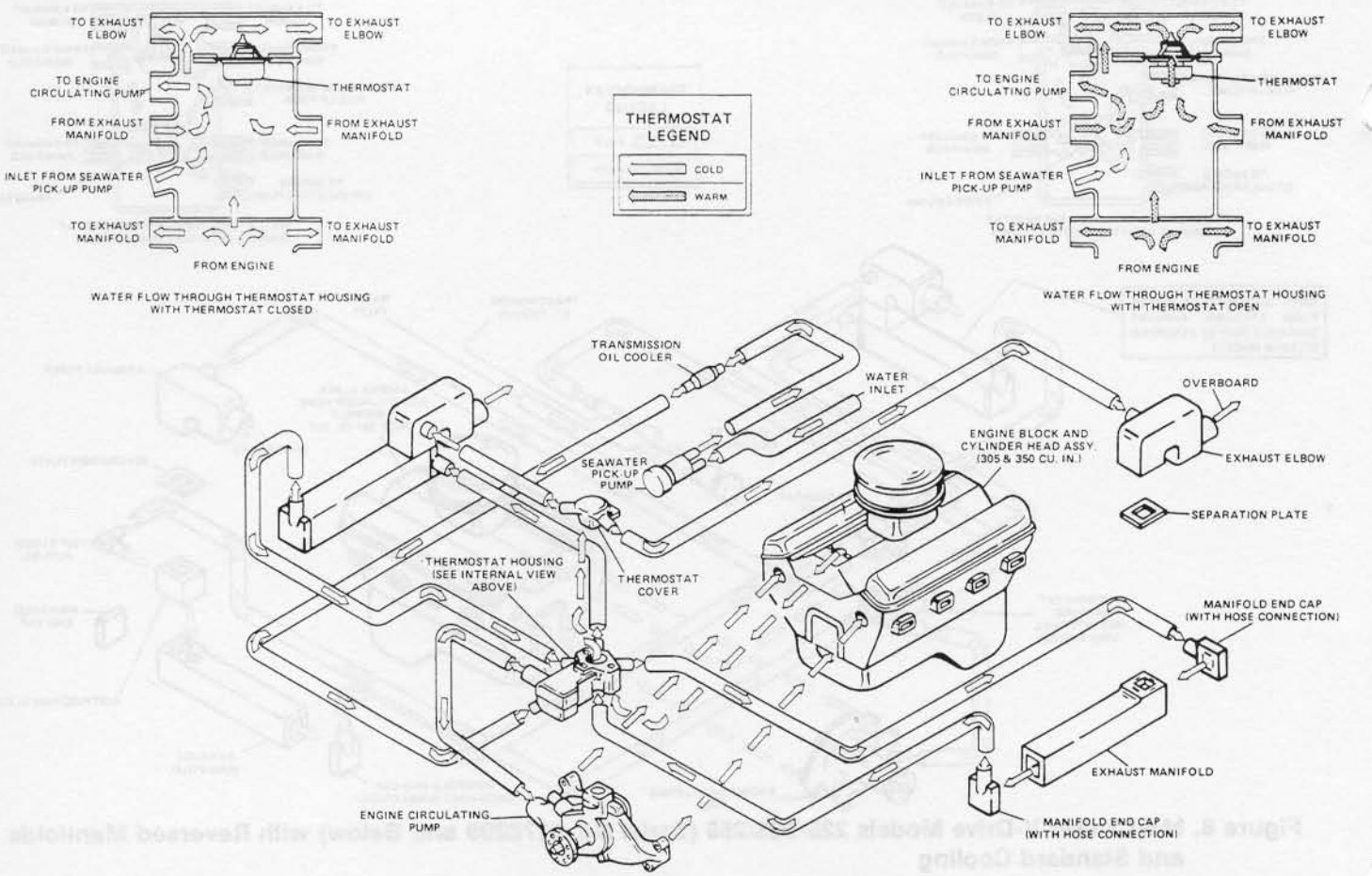


Figure 10. MerCruiser Inboard Models 198/228/255 (Serial No. 4775000 and Above) with Standard Cooling

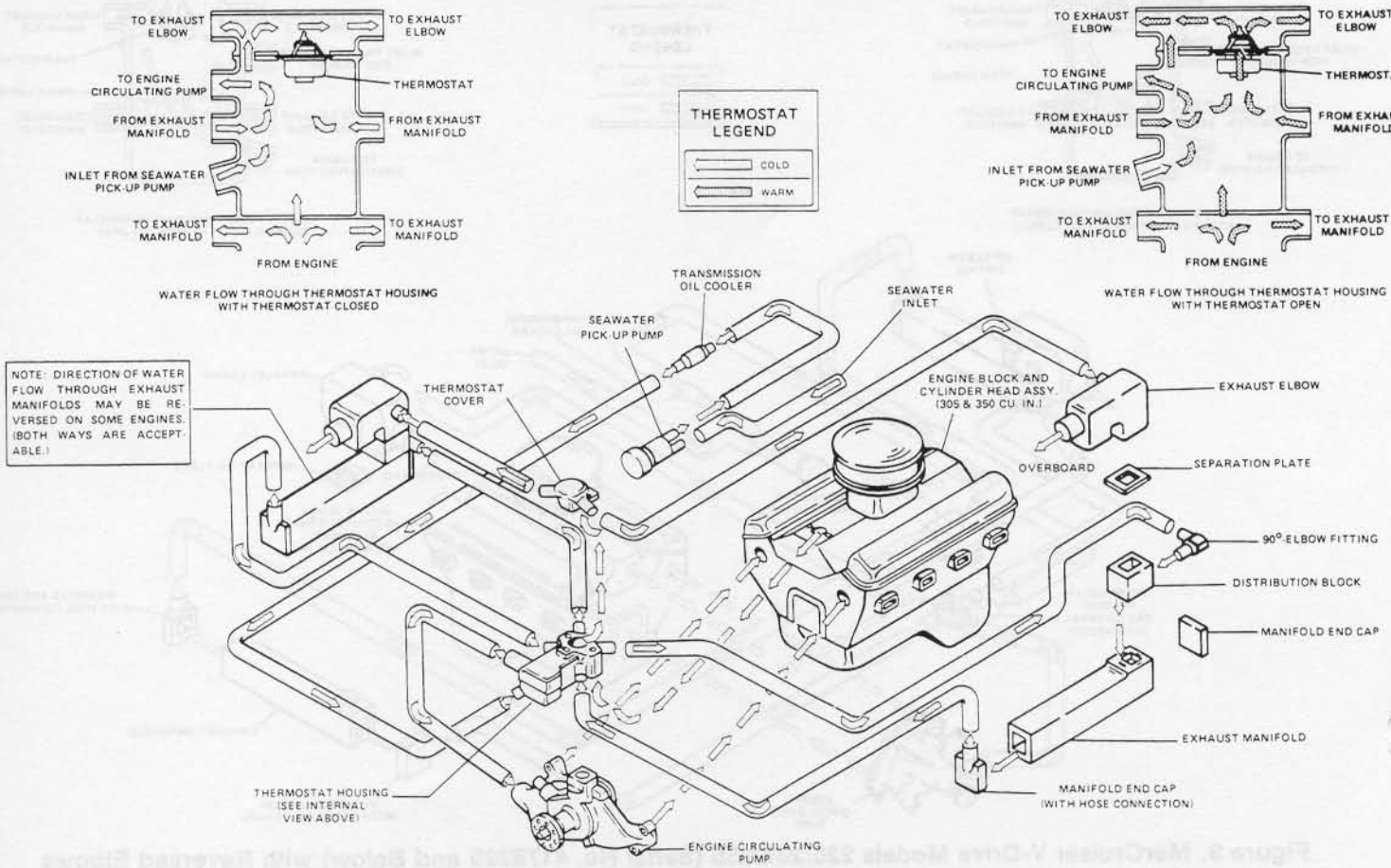


Figure 11. MerCruiser V-Drive Models 198/228/255 (Serial No. 4775000 and Above) with Standard Cooling

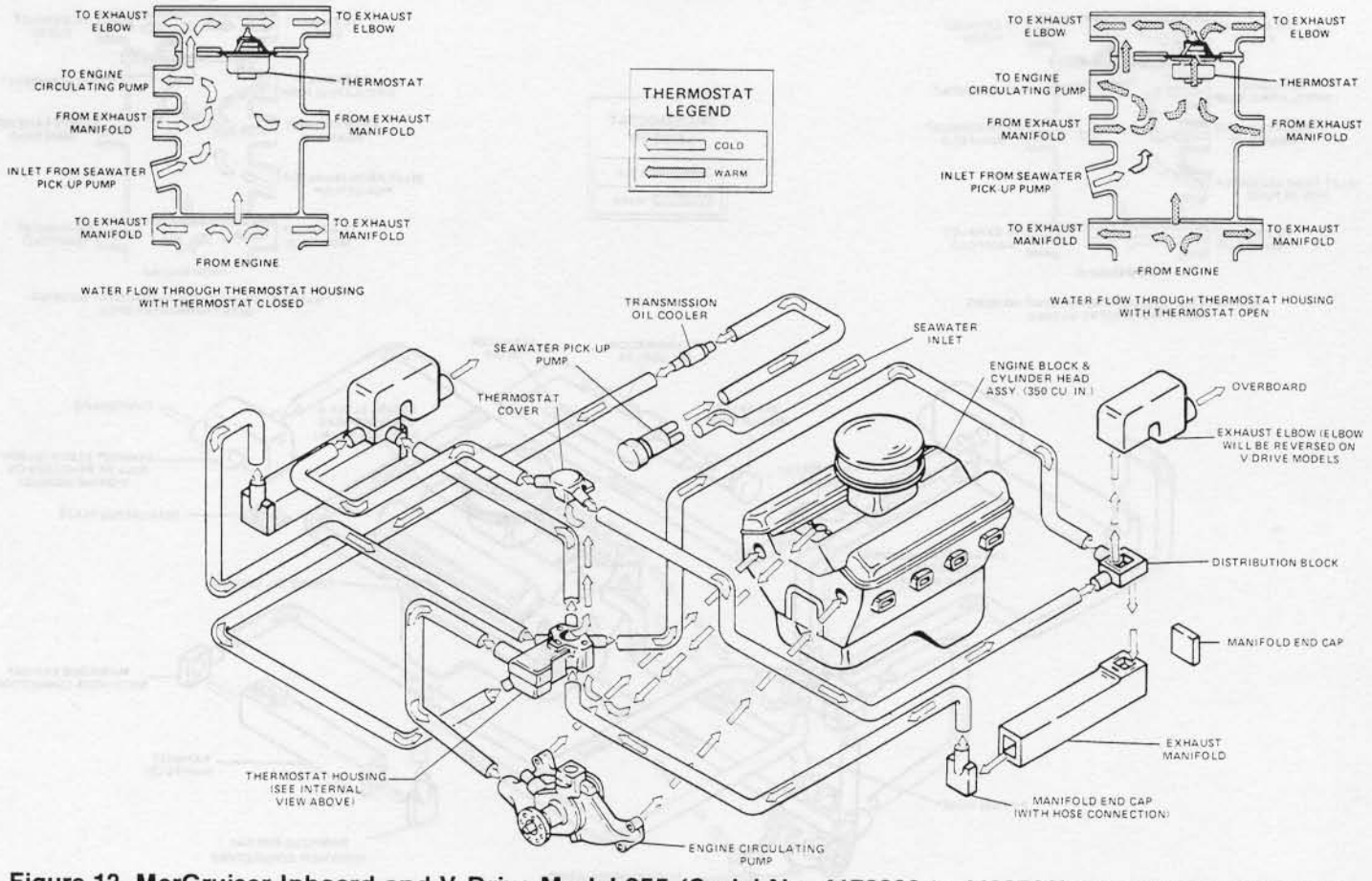


Figure 12. MerCruiser Inboard and V-Drive Model 255 (Serial No. 4178300 to 4498700) with Standard Cooling

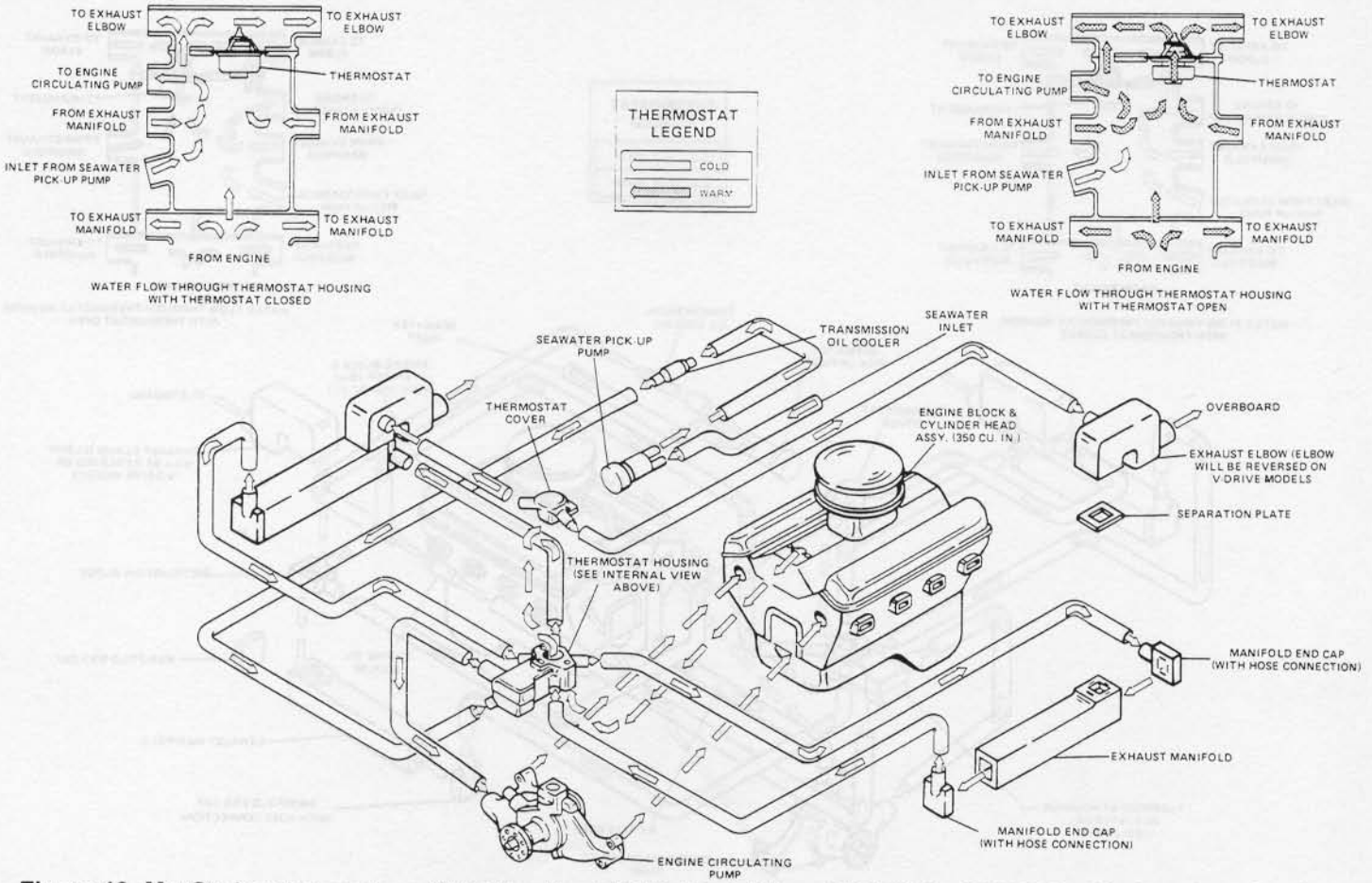


Figure 13. MerCruiser Inboard and V-Drive Model 255 (Serial No. 4498701 to 4774999) with Standard Cooling

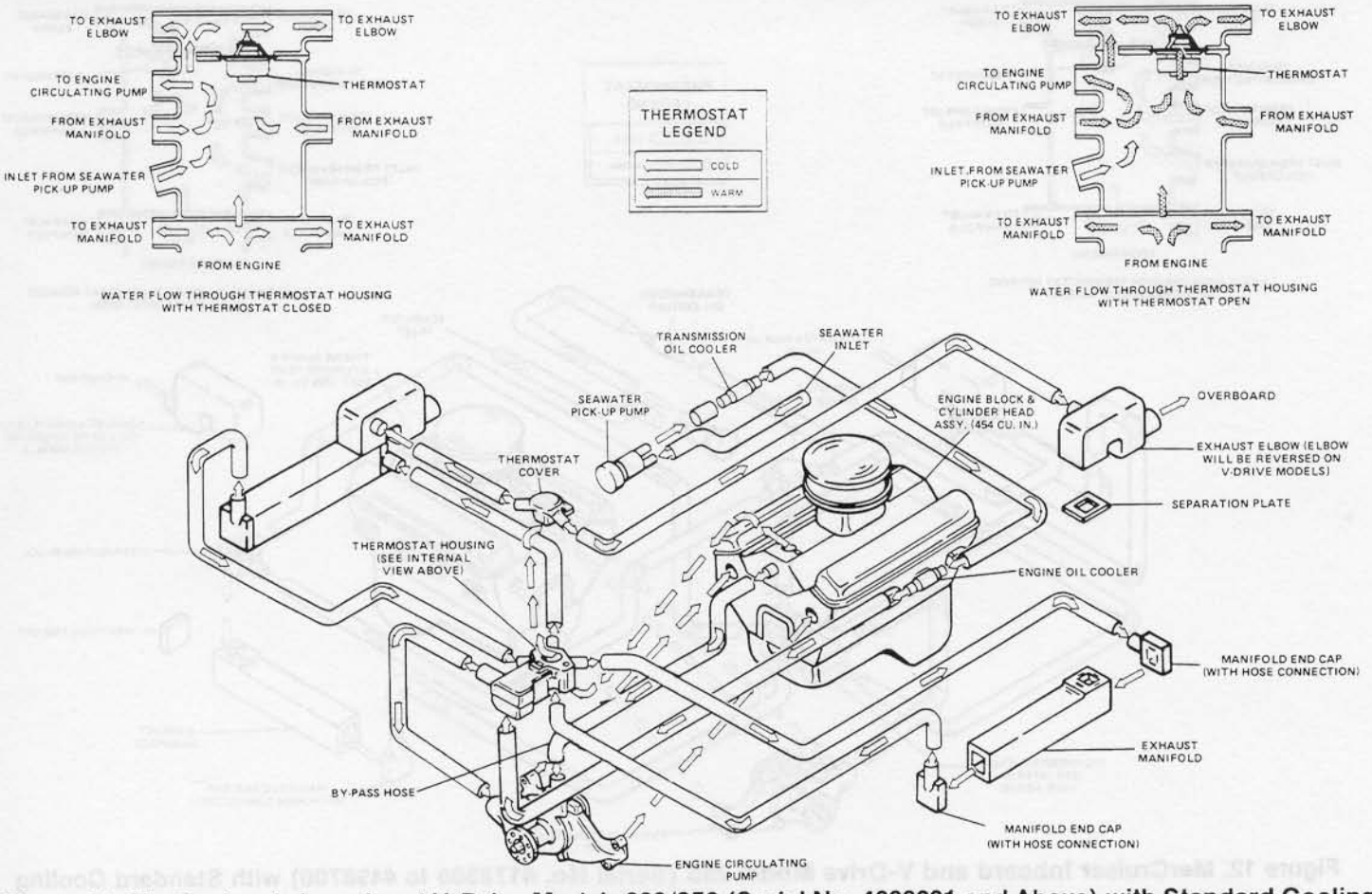


Figure 14. MerCruiser Inboard and V-Drive Models 330/350 (Serial No. 4338221 and Above) with Standard Cooling

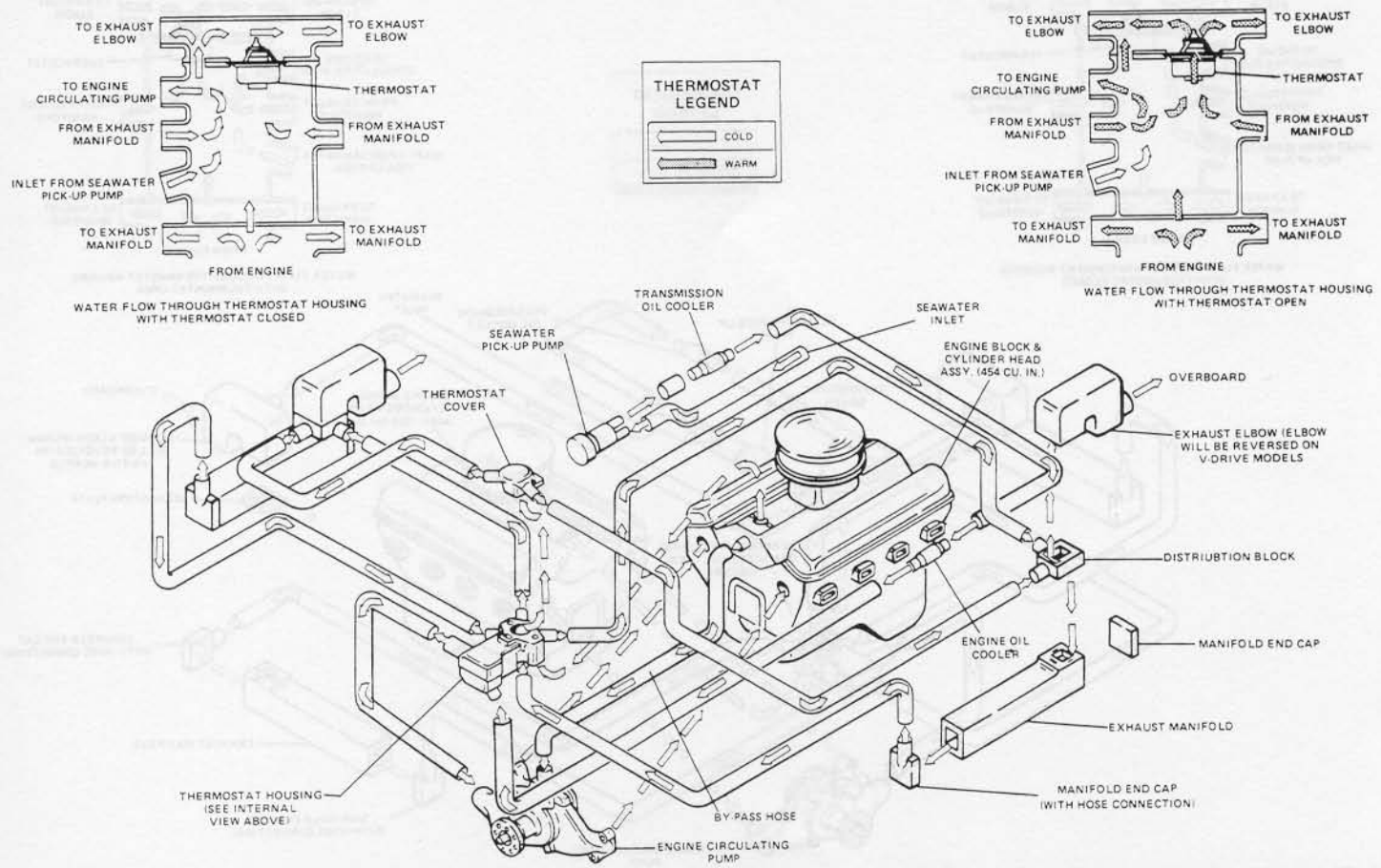


Figure 15. MerCruiser Inboard and V-Drive Model 350 (Serial No. 4338220 and Below) with Standard Cooling

Closed Cooling System

MerCruiser engines with Closed Cooling incorporate a heat exchanger which is a device used to transfer heat from one body of water to another without the 2 ever coming in direct contact or mixing. See Closed Cooling System "flow diagrams", following. This enables the cooling system to be separated into 2 individual sections (the fresh water section and the seawater section), thus allowing the engine to be cooled with fresh (uncontaminated) water which, in turn, is cooled in the heat exchanger by the seawater. In this way, engine cooling is achieved without the seawater ever contacting the water passages within the engine, thereby preventing corrosion and the accumulation of deposits and debris that might otherwise occur. This system can greatly increase engine life and provide better engine efficiency.

The fresh water section (or closed section) is filled with a coolant such as a solution of ethylene glycol (anti-freeze) and water or a solution of rust inhibitor and water. A centrifugal type circulating pump (located over an opening in the front of the engine block) is used to circulate the coolant through the engine block, cylinder head(s) and manifold(s), thus removing the heat given off by these parts as the coolant passes. The heated coolant then is routed to the heat exchanger where it is cooled (to be explained later). After the coolant passes through the heat exchanger, it is routed back to the circulating pump where it again is re-circulated.

The seawater section incorporates an impeller type pickup pump (located in the stern drive, or it is belt driven at the front of the engine) that pumps seawater through the seawater section of the heat exchanger. (If engine is equipped with a Power Steering, transmission or engine oil cooler, seawater passes through and removes heat from it before going to the heat exchanger). As it passes through the heat exchanger, the seawater absorbs the heat given off by the fresh water (as will be explained in next paragraph). After the seawater has passed through the heat exchanger, it and the absorbed heat are expelled overboard through the exhaust elbows.

The heat exchanger is the shell-and-tube type and consists of a group of equally-spaced, parallel, copper tubes through which the seawater flows. These tubes are encased in a large copper shell through which the fresh water flows, thereby enabling the fresh water to contact the outer walls of the tubes. This allows the heat (absorbed in the fresh water) to pass through the walls of the tubes where it is absorbed by the seawater on the inside. The heated seawater then is discharged overboard, while the fresh water, which has given up its heat, is routed back to the circulating pump.

A thermostatic heat control is incorporated into the fresh water section (located over the coolant outlet passage from the engine) that regulates coolant flow to the heat exchanger in relation to engine temperature, thereby providing fast engine warmup and regulated operating temperature.

The thermostat is basically a control valve that is activated by a pellet-type thermostatic element. When the coolant is cold, the thermostat remains closed, thus restricting coolant flow to the heat exchanger and allowing the engine to warm the coolant (within the block) quickly and evenly. When the coolant reaches operating temperature, the thermostat opens, permitting coolant within the engine to flow to the heat exchanger and be cooled. The thermostat then continues to close and open, as needed, to maintain the coolant at operating normal temperature.

The fresh water section also is pressurized to raise the boiling point of the coolant, thereby allowing higher operating temperatures and increased engine efficiency.

TROUBLESHOOTING

Use the following Closed Cooling System "flow diagrams" and "Engine Overheating" trouble chart in Section 10 of this Service Manual (see Sec. 10 "Index") as aids to troubleshooting Closed Cooling Systems.

Closed Cooling System Flow Diagrams

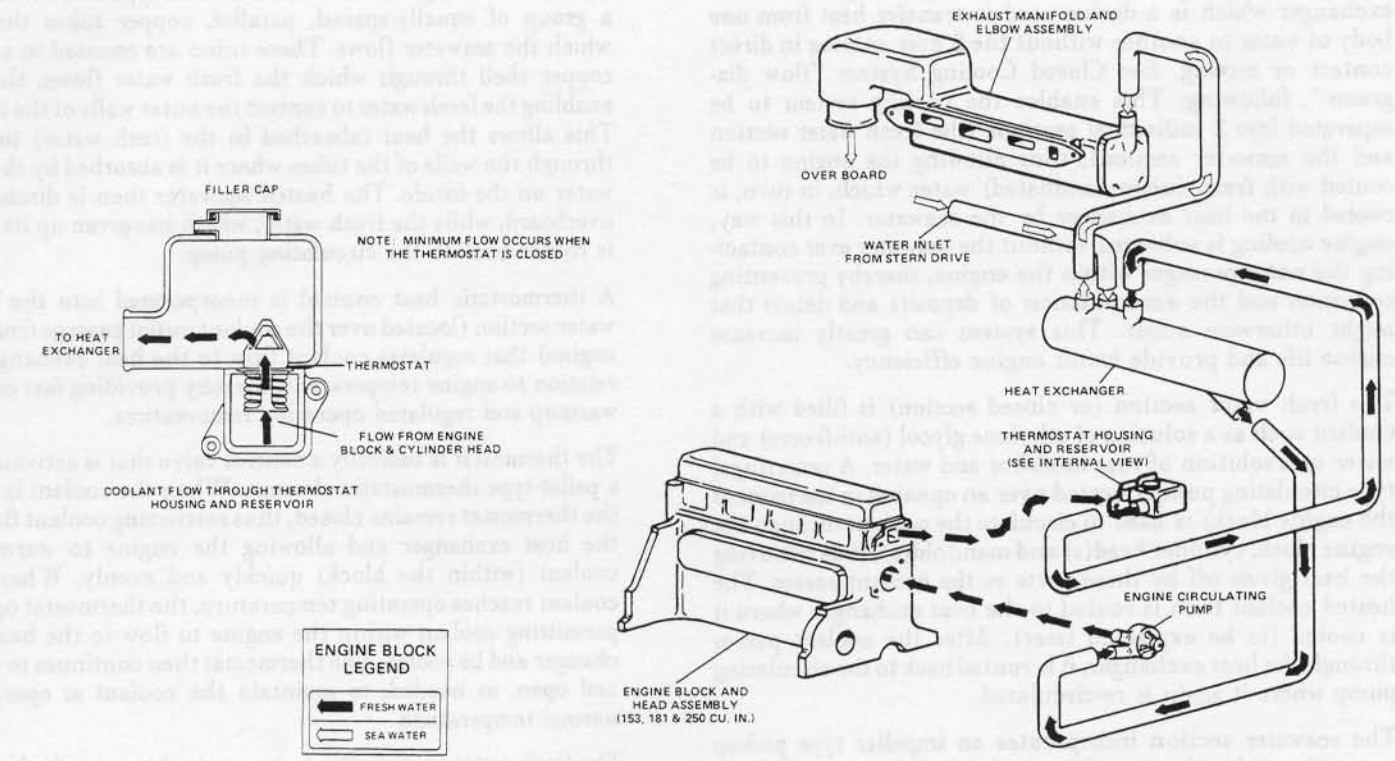


Figure 1. MerCruiser Stern Drive Models 120/140/165 with Closed Cooling

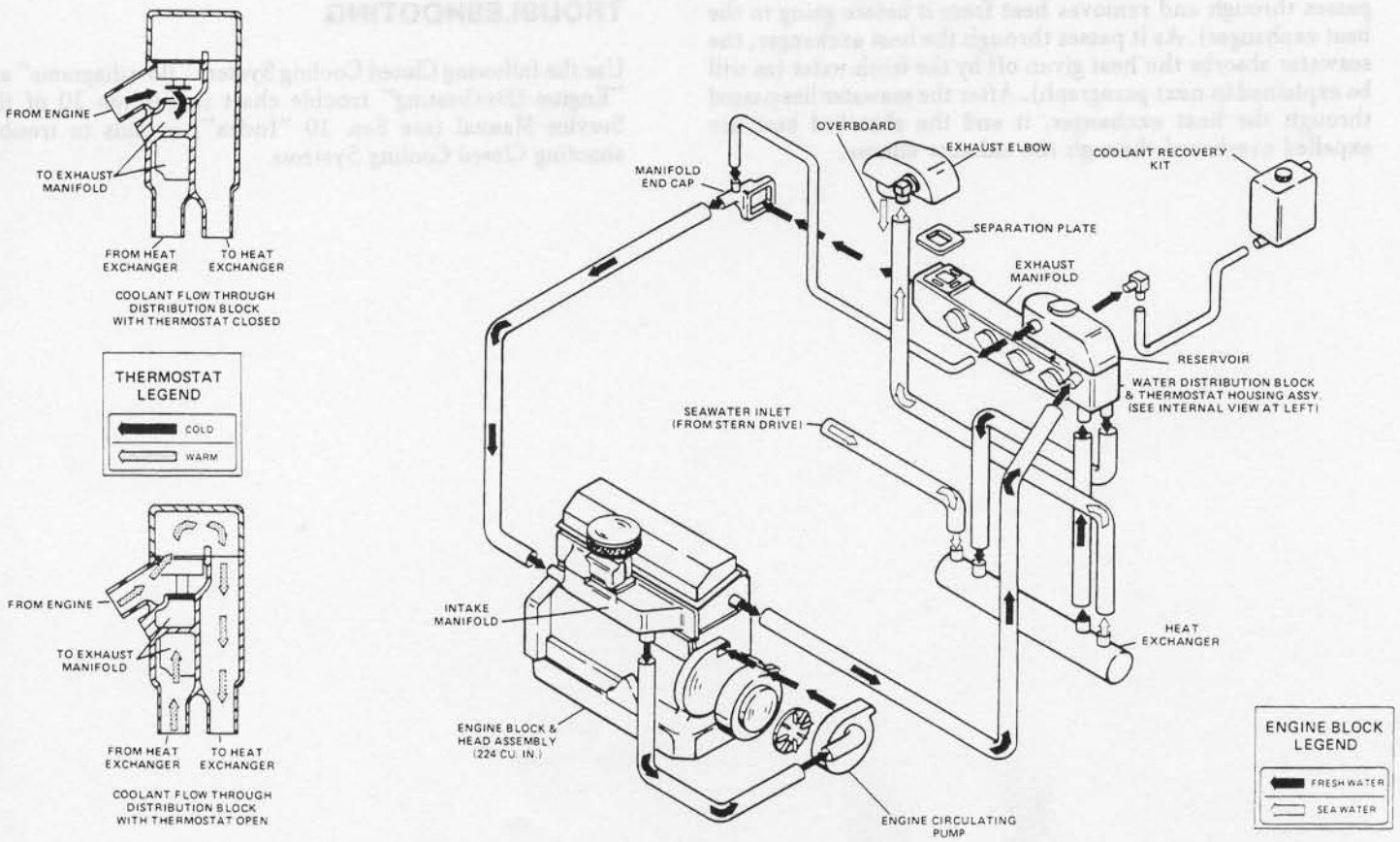


Figure 2. MerCruiser Stern Drive Model 470 (Serial No. 4886619 and Below) with Closed Cooling (Standard Equipment)

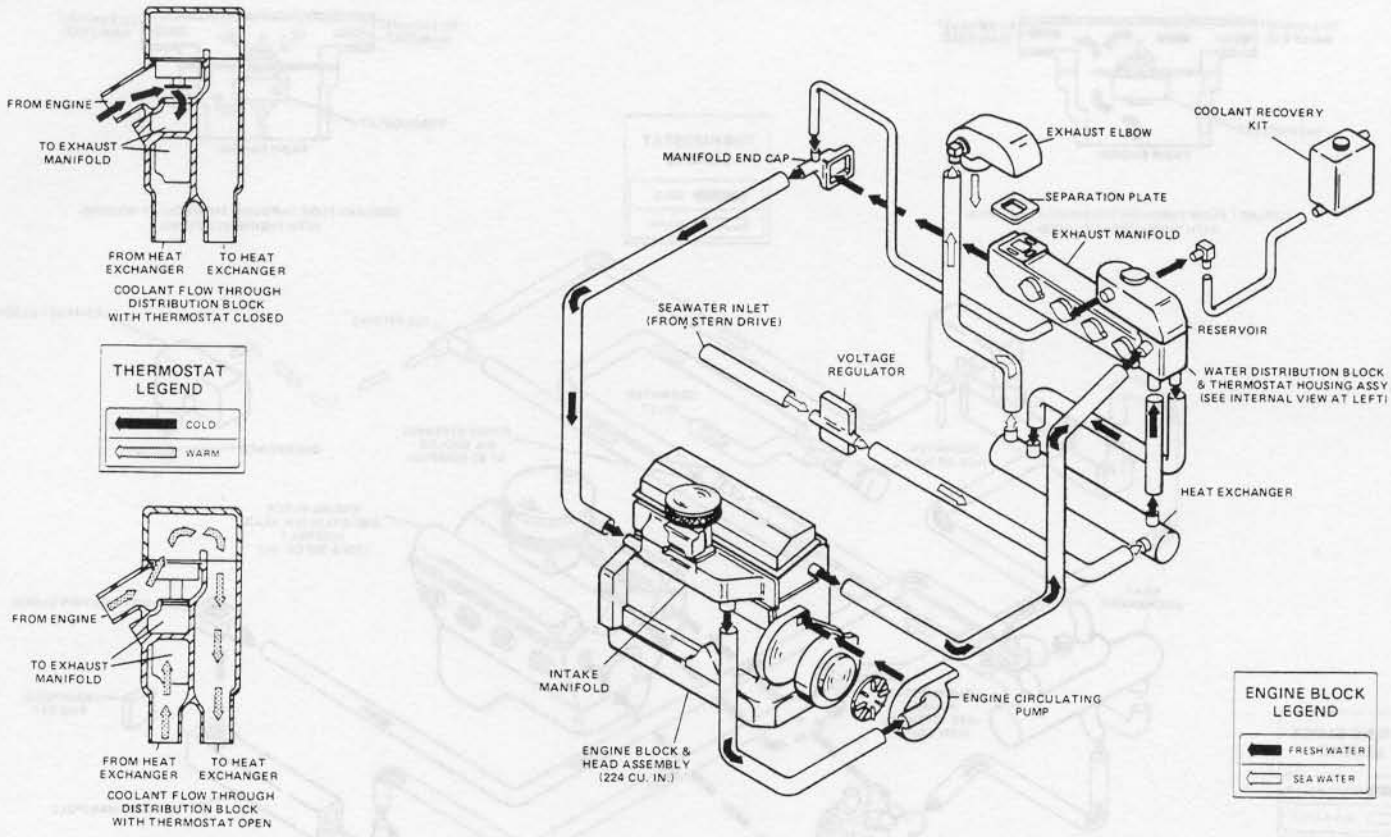


Figure 3. MerCruiser Stern Drive Model 470 (Serial No. 4886620 and Above) with Closed Cooling (Standard Equipment)

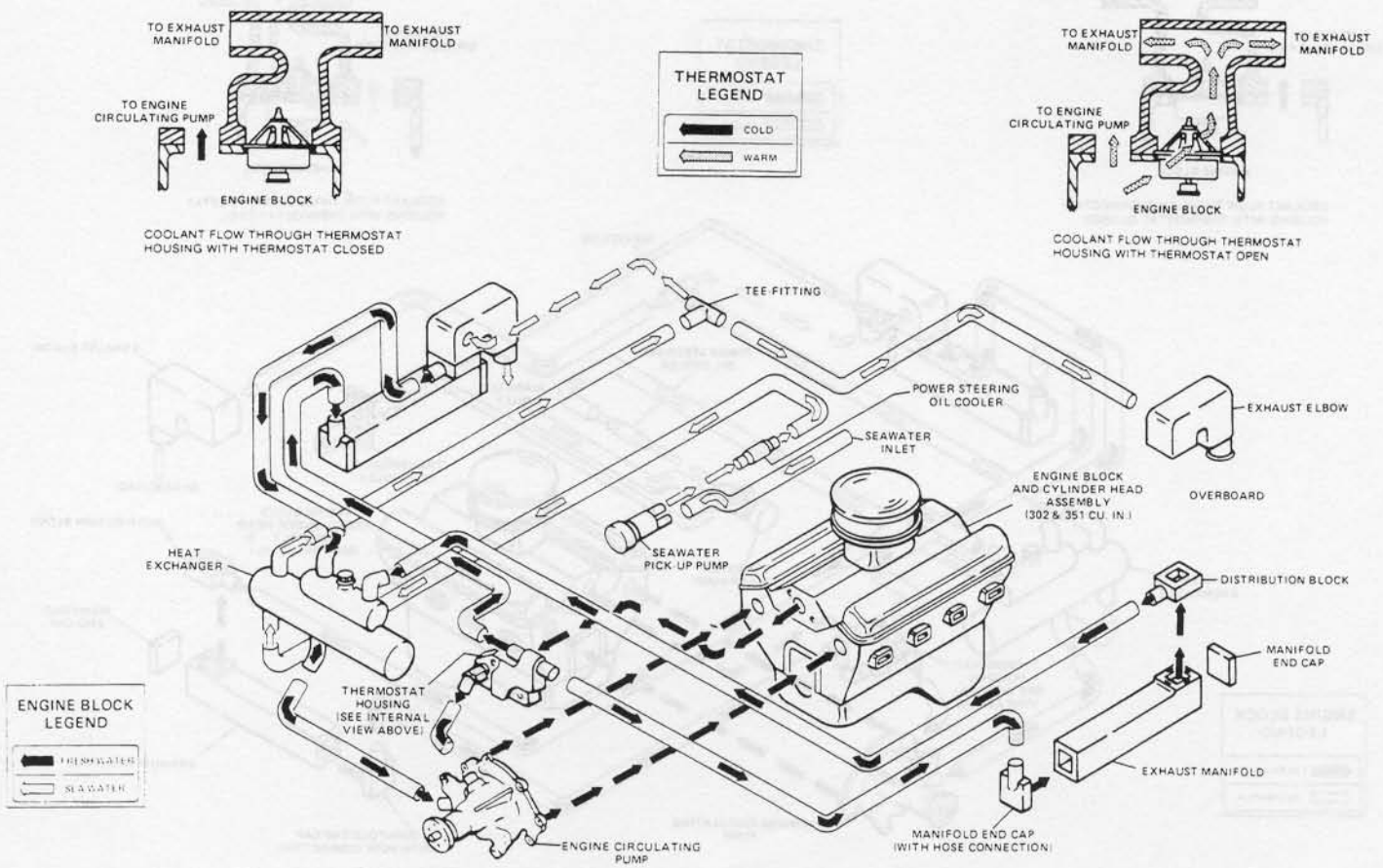


Figure 4. MerCruiser Stern Drive Models 888/225-S/233 with Closed Cooling

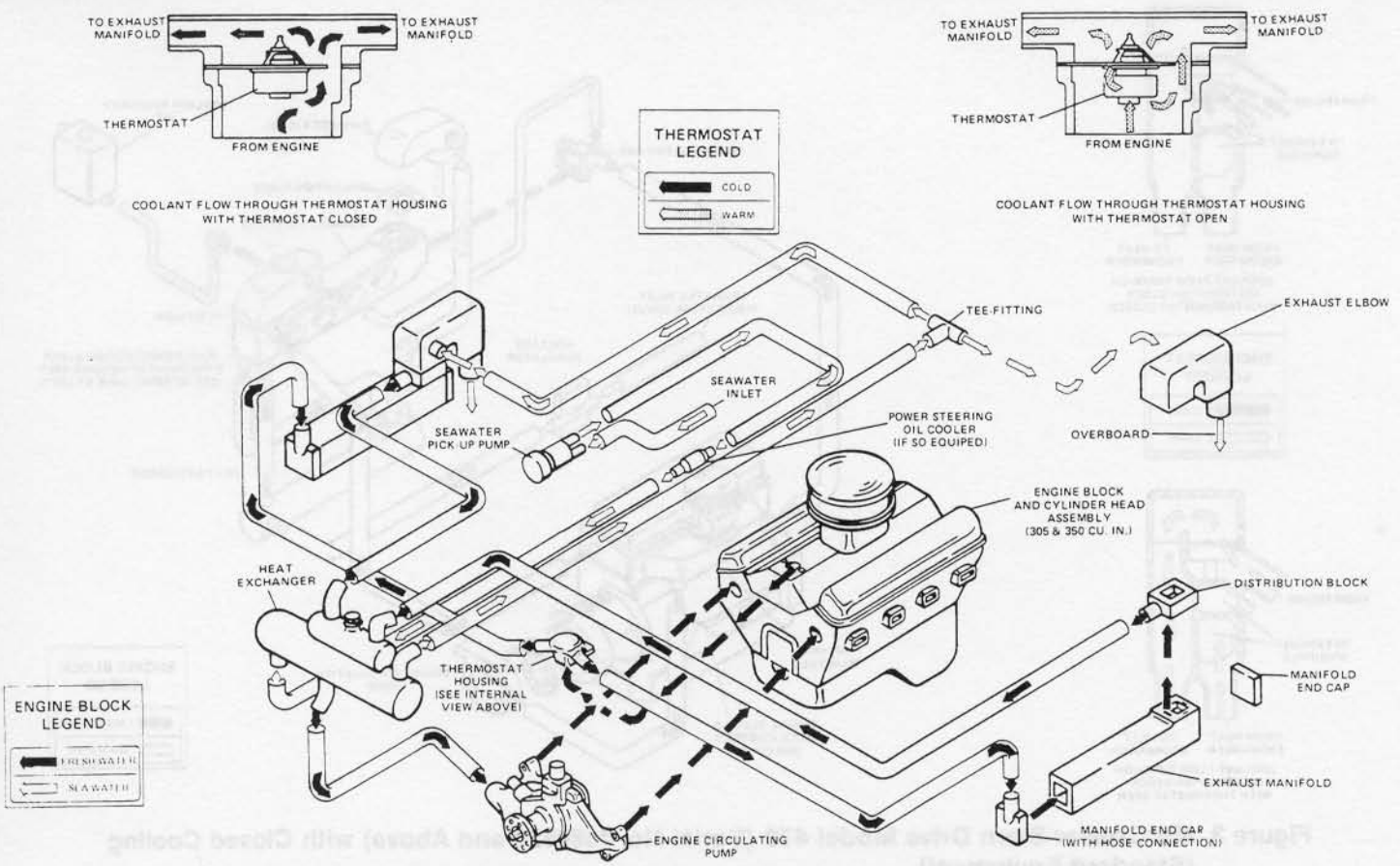


Figure 5. MerCruiser Stern Drive Models 898/228/250/260 with Closed Cooling

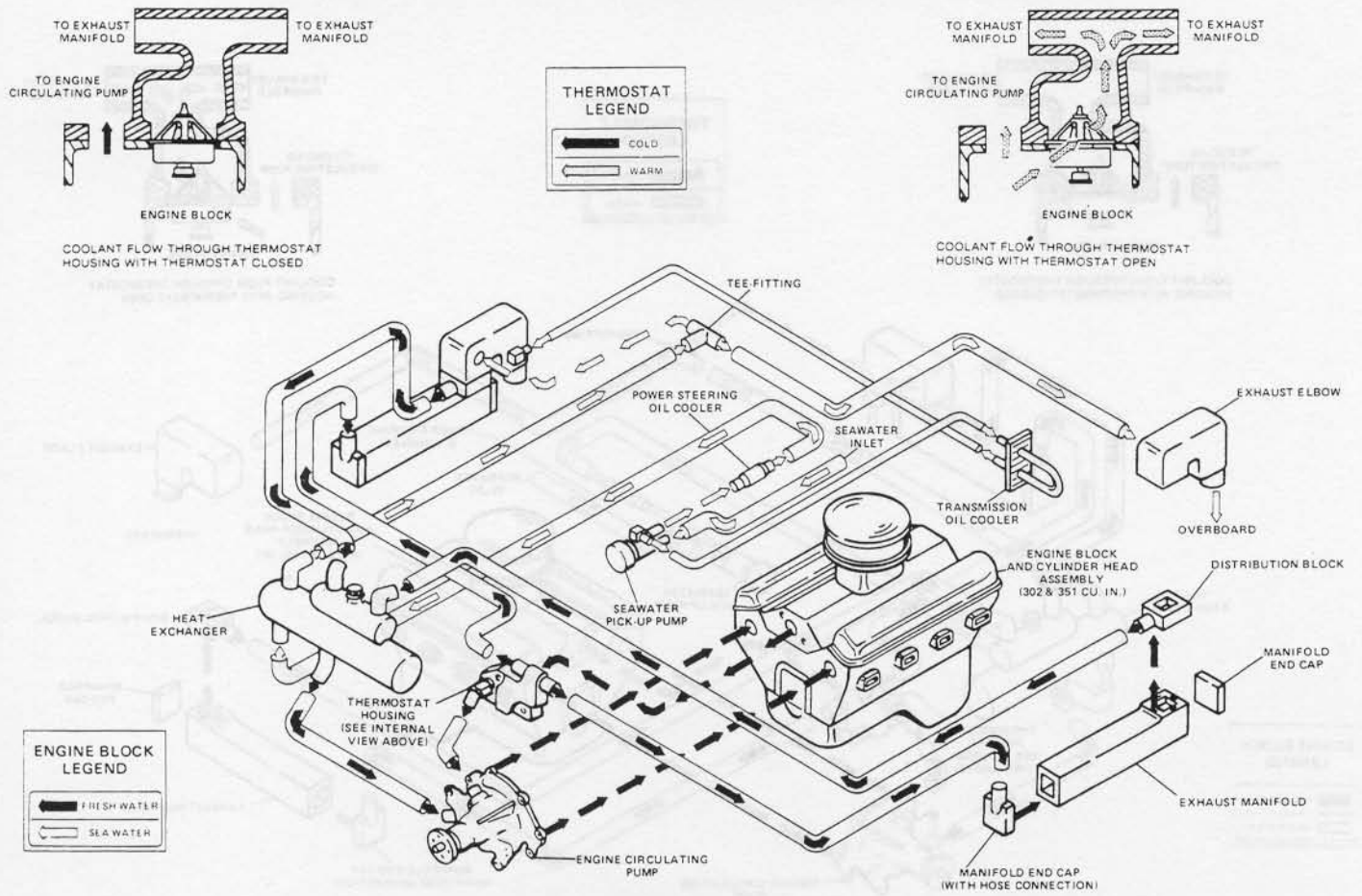


Figure 6. MerCruiser Stern Drive Models 225II-TR, 255II-TR (Serial No. 4175499 and Below) and 255II-TRS with Closed Cooling

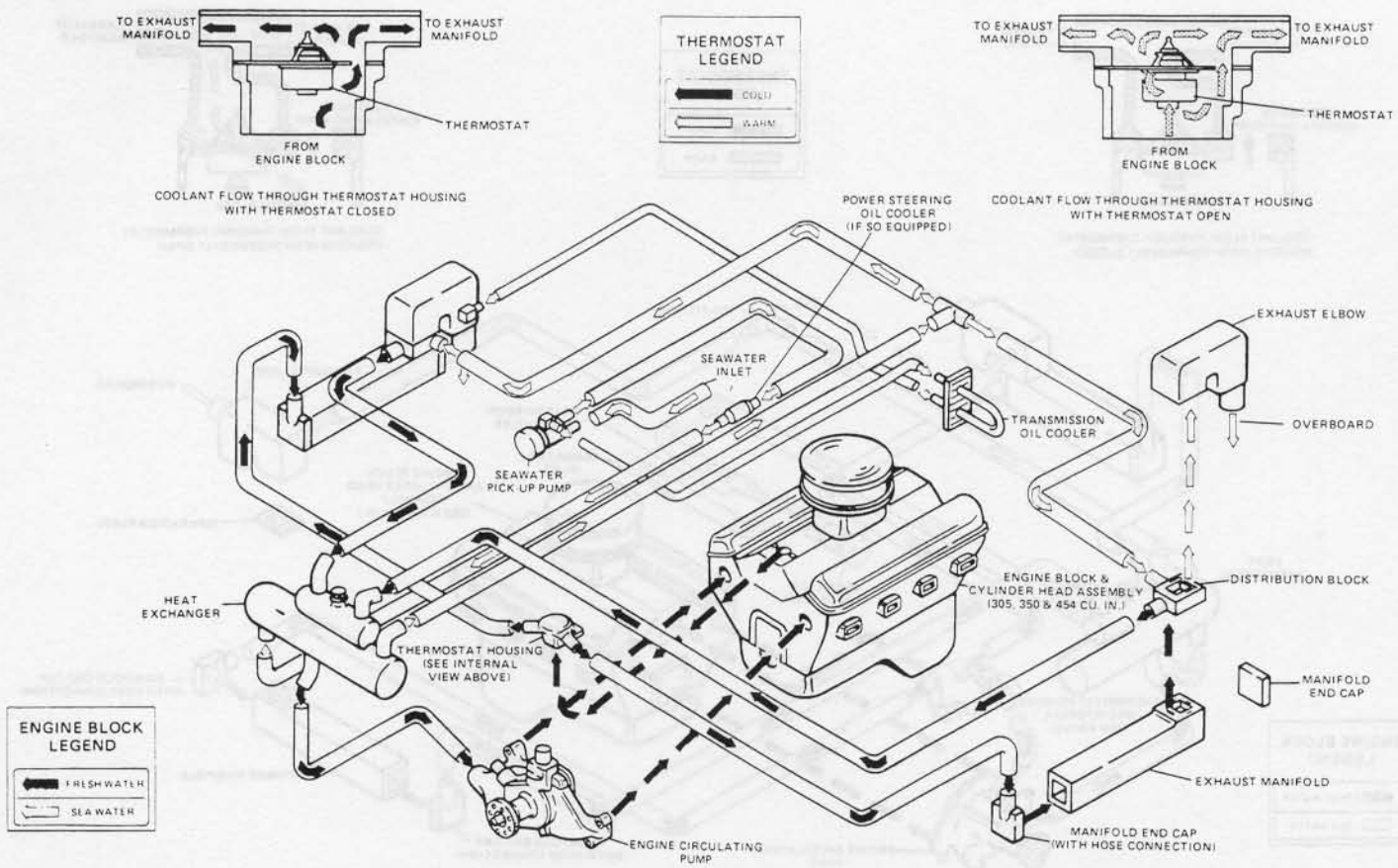


Figure 7. MerCruiser Stern Drive Models 228II-TR (Serial No. 4888929 and Below), 255II-TR (Serial No. 4175500 and Above), 280II-TRS, 330II-TR and 330II-TRS with Closed Cooling

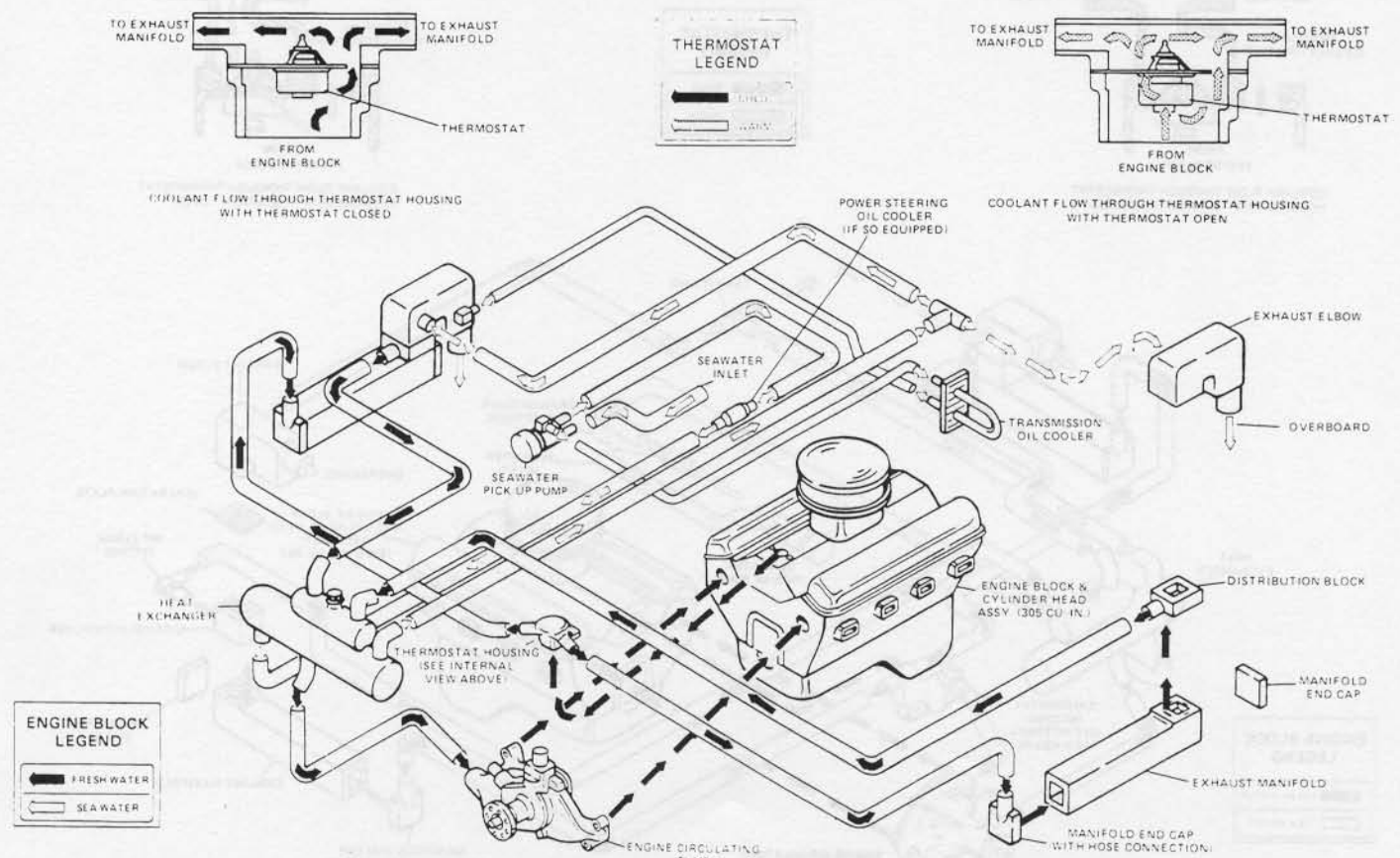


Figure 8. MerCruiser Stern Drive Model 228II-TR (Serial No. 4888930 and Above) with Closed Cooling

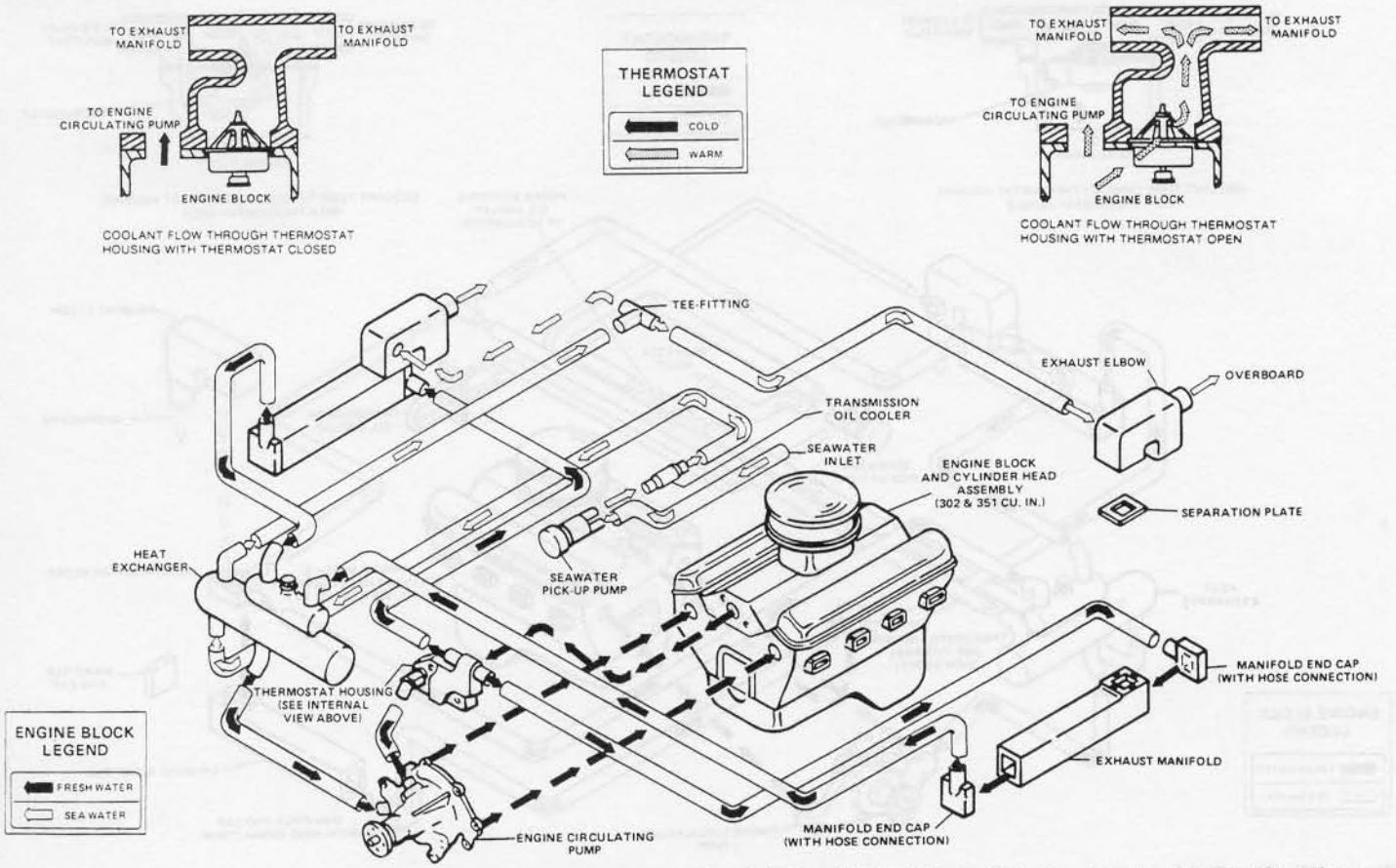


Figure 9. MerCruiser Inboard Models 225/233/255 (Serial No. 4178299 and Below) with Closed Cooling

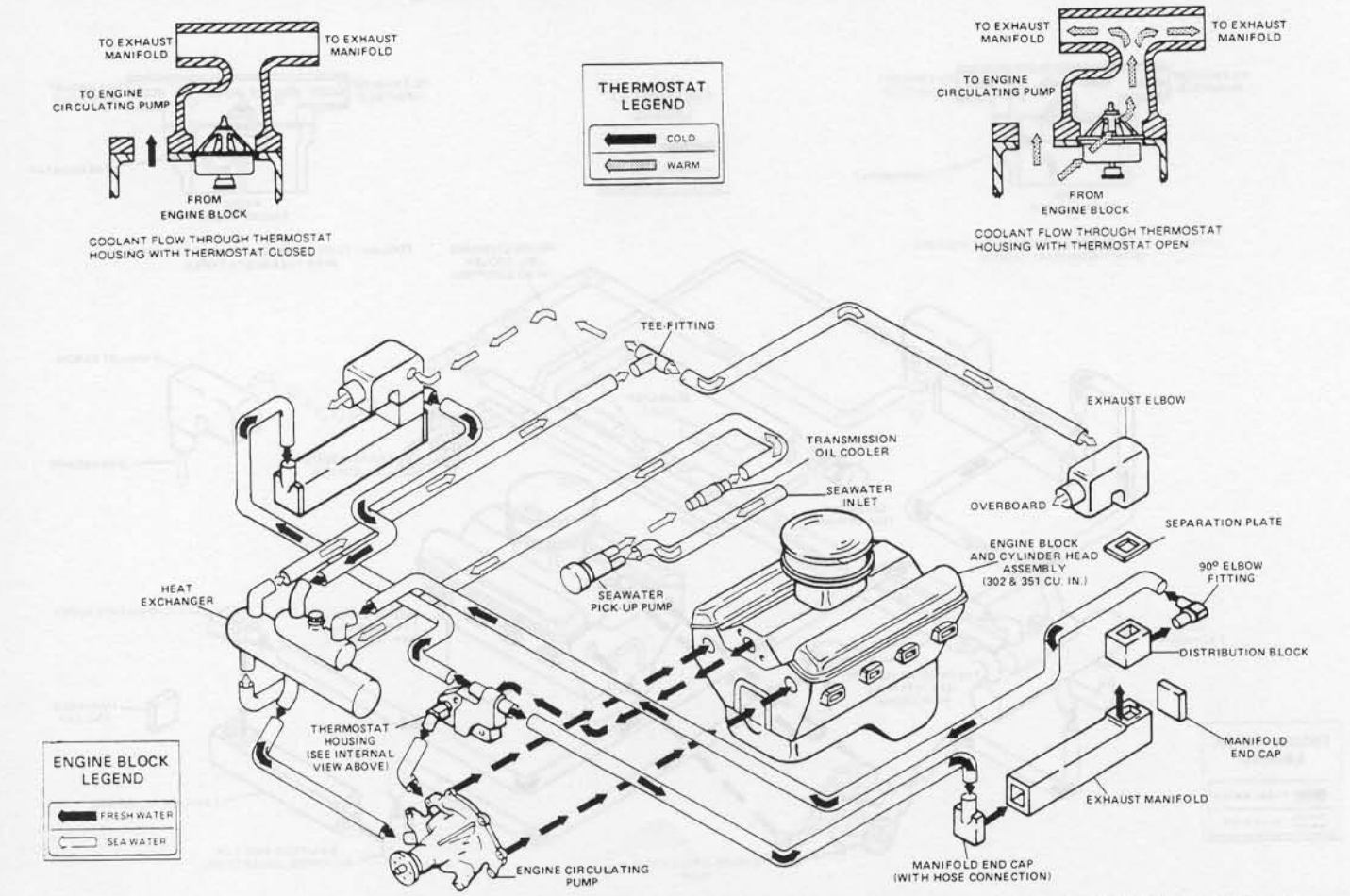


Figure 10. MerCruiser V-Drive Models 225/233/255 (Serial No. 4178299 and Below) with Closed Cooling

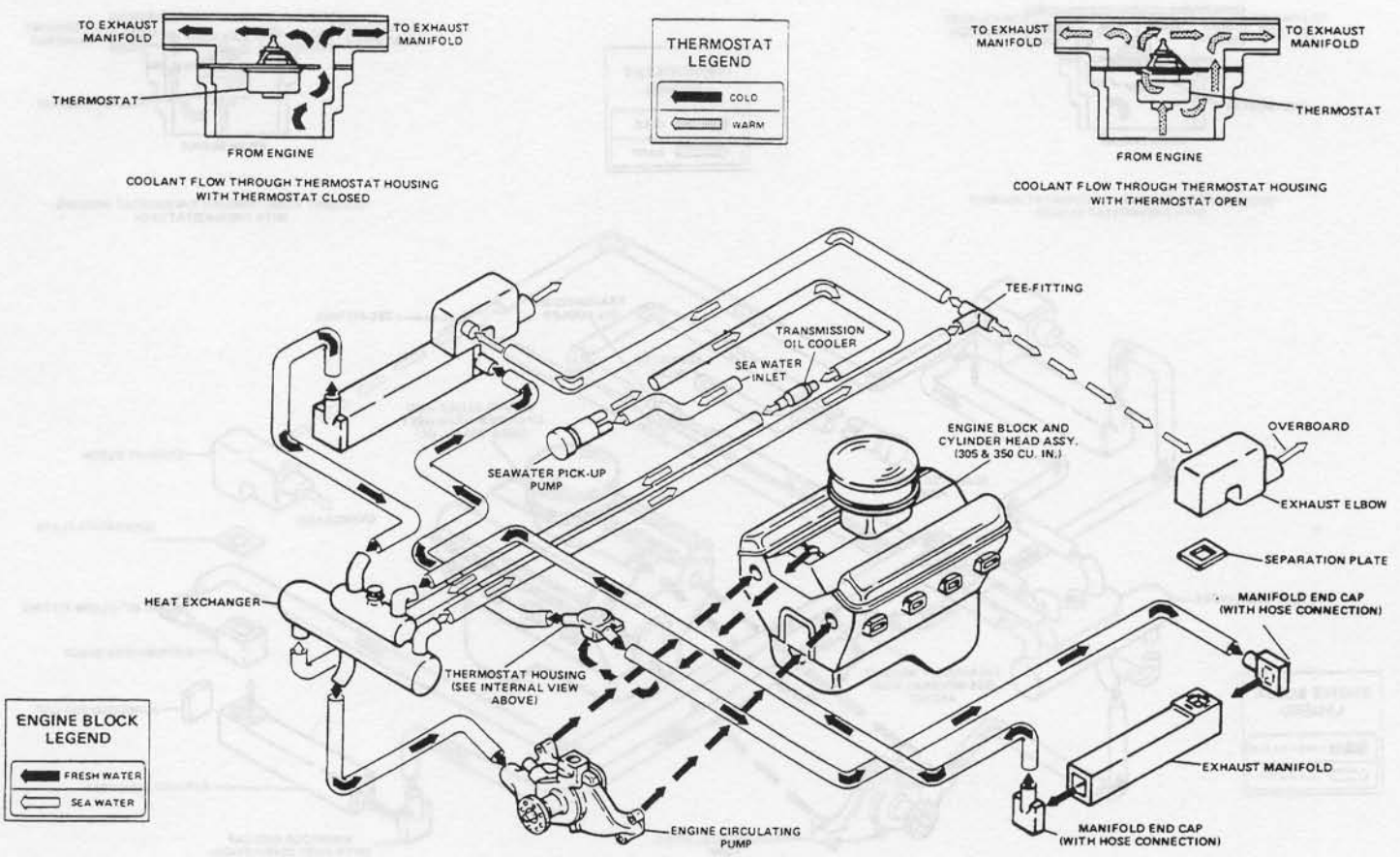


Figure 11. MerCruiser Inboard Models 198/228/255 (Serial No. 4498701 and Above) with Closed Cooling

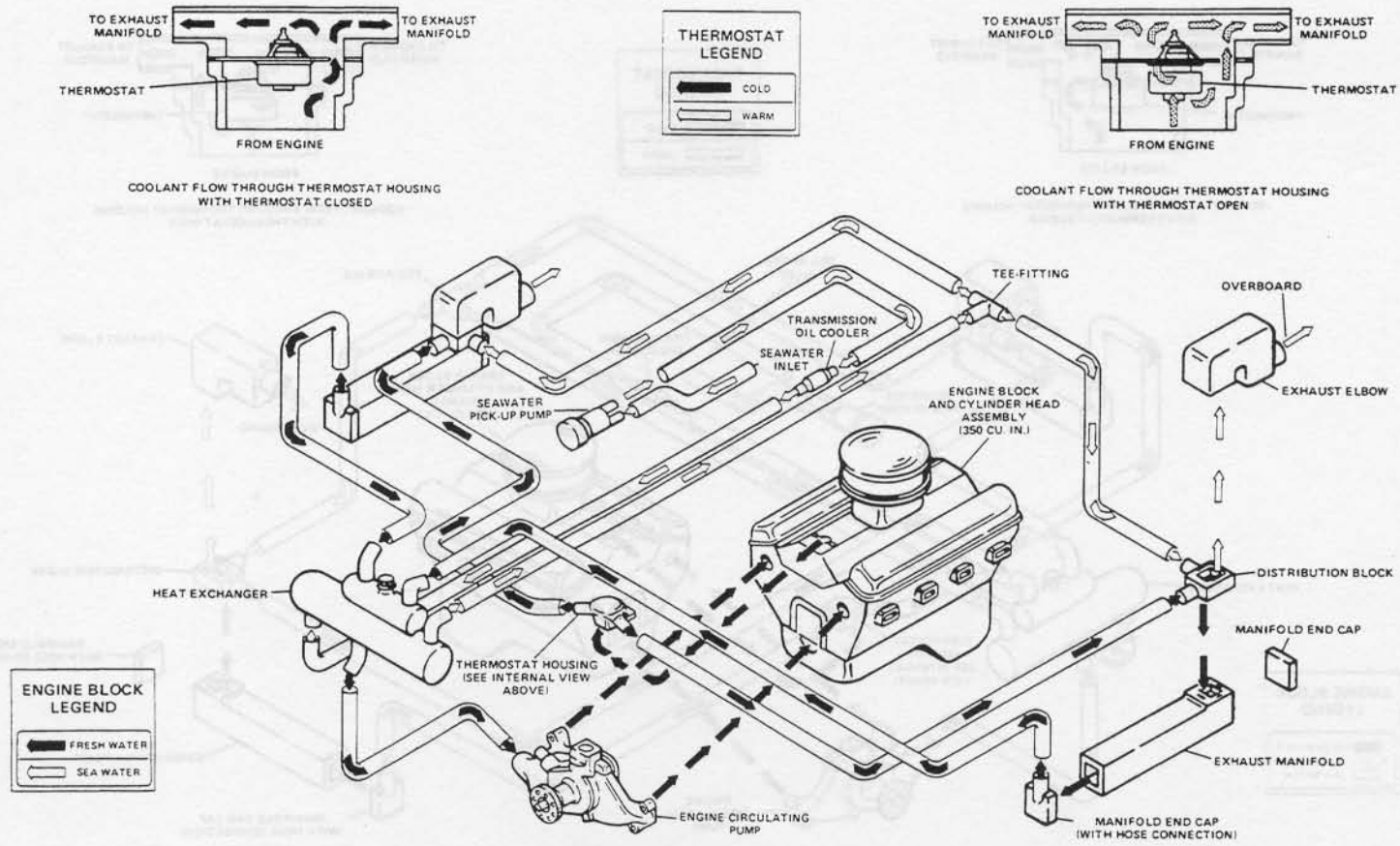


Figure 12. MerCruiser Inboard Model 255 (Serial No. 4178300 to 4498700) with Closed Cooling

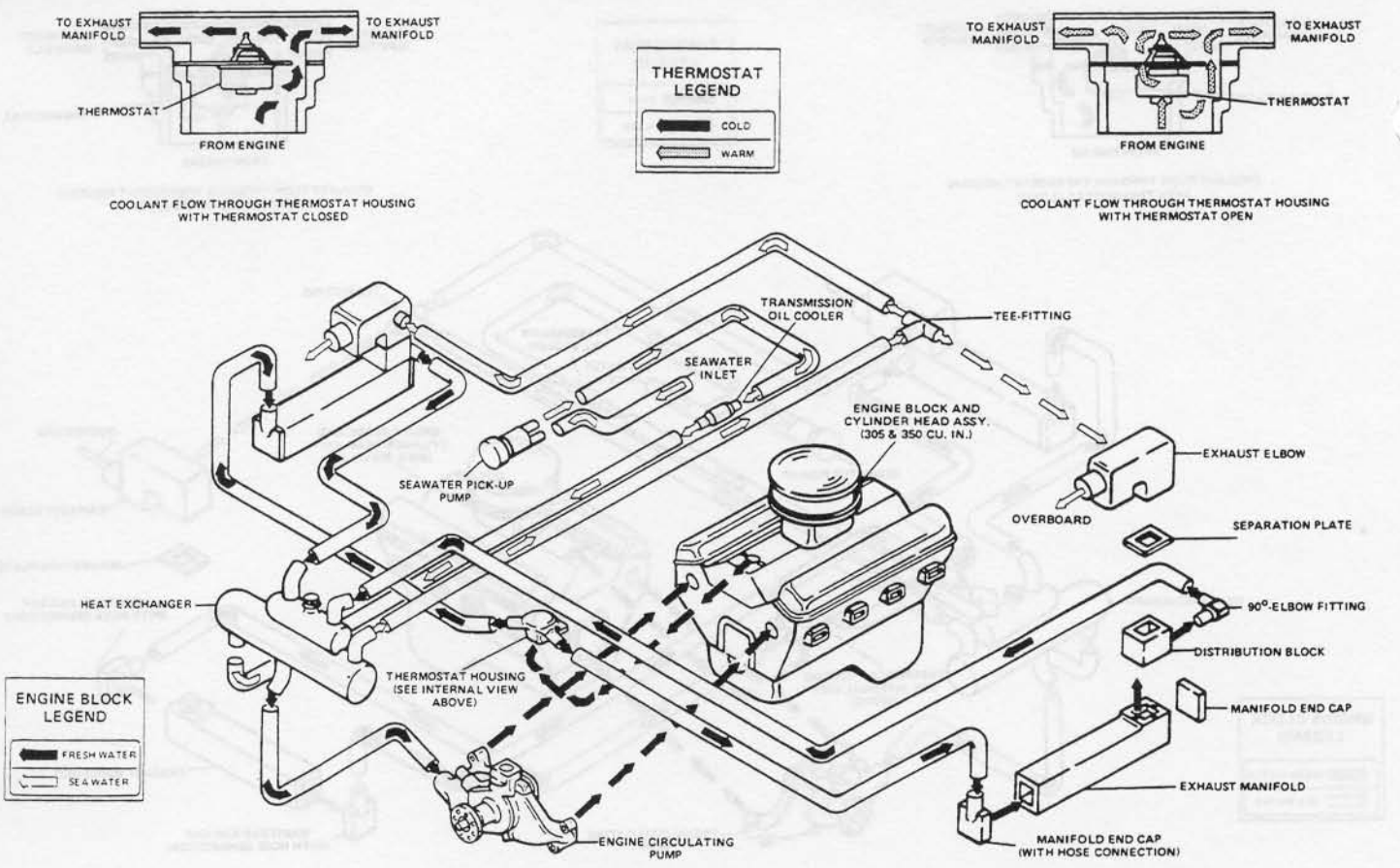


Figure 13. MerCruiser V-Drive Models 198/228/255 (Serial No. 4775000 and Above) with Closed Cooling

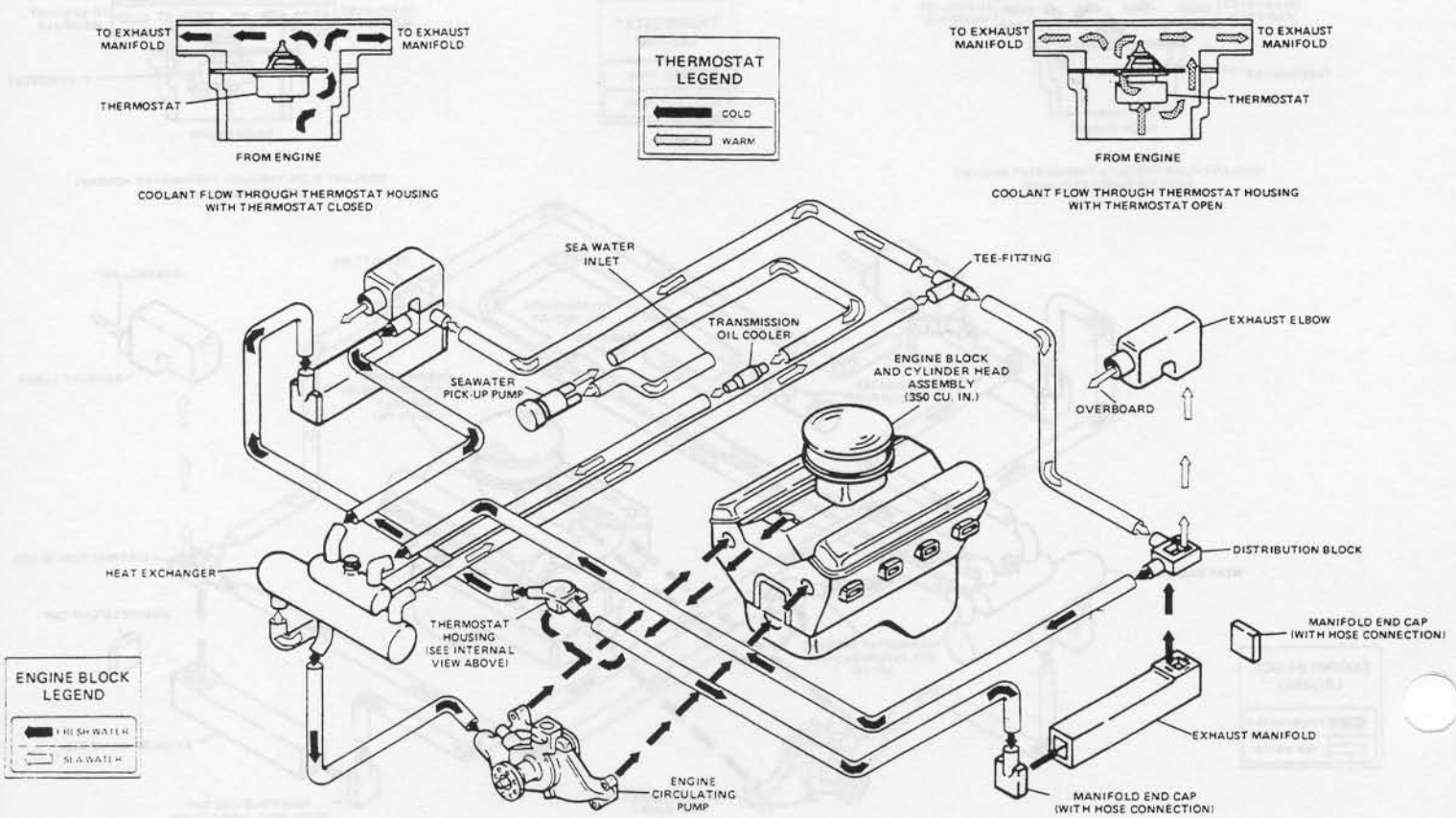


Figure 14. MerCruiser V-Drive Model 255 (Serial No. 4178300 to 4774999) with Closed Cooling

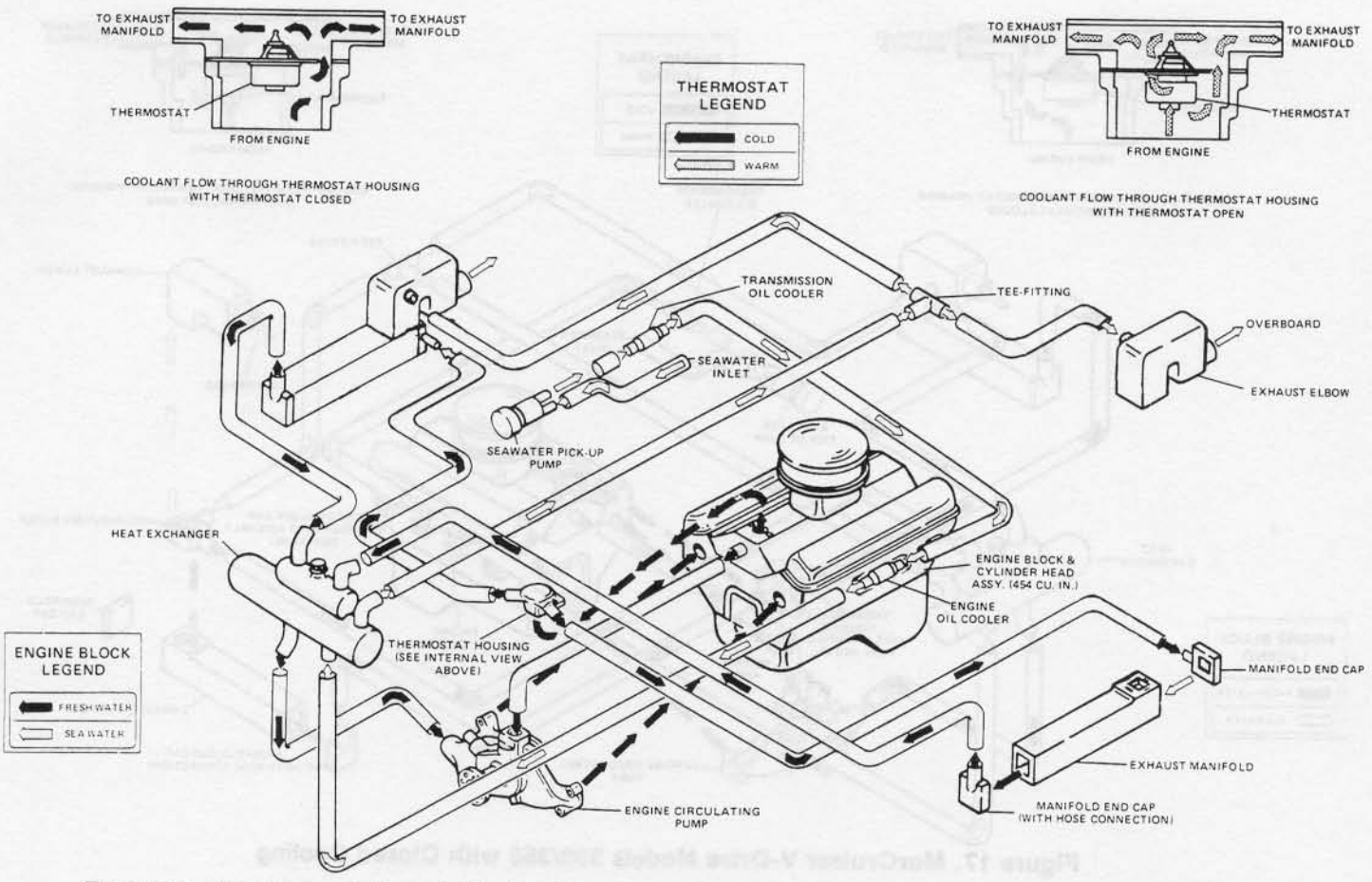


Figure 15. MerCruiser Inboard Models 330/350 (Serial No. 4338221 and Above) with Closed Cooling

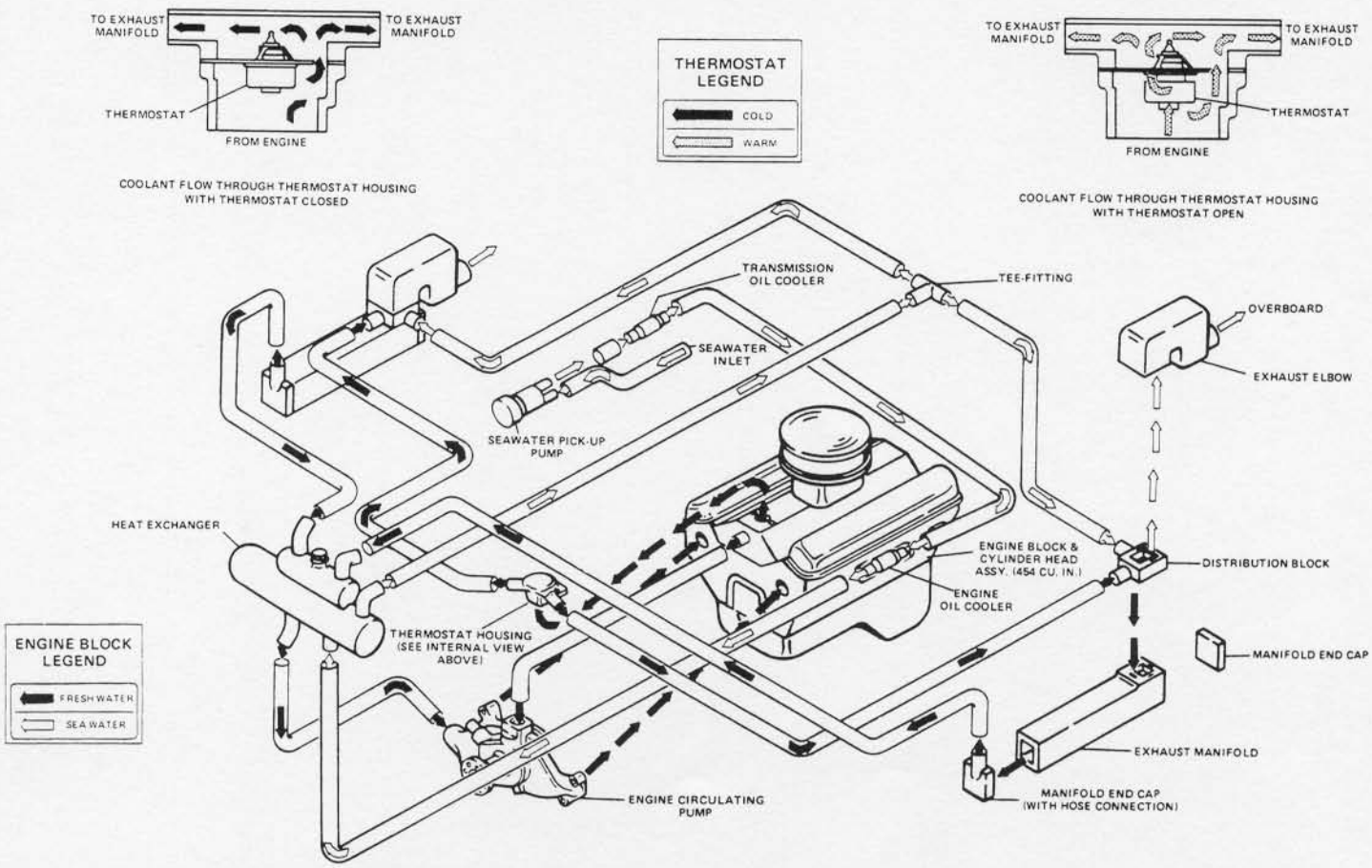


Figure 16. MerCruiser Inboard Model 350 (Serial No. 4338220 and Below) with Closed Cooling

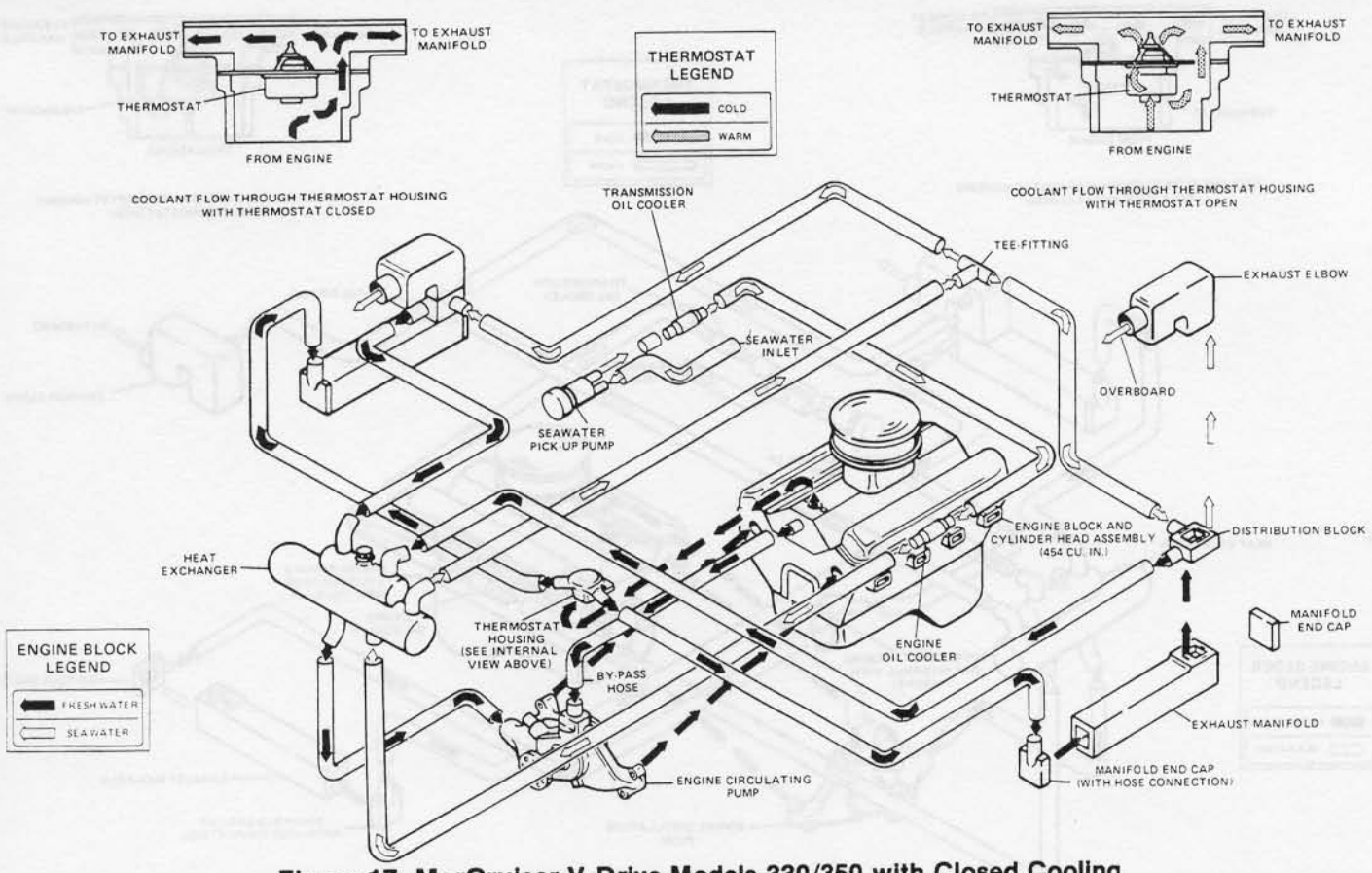
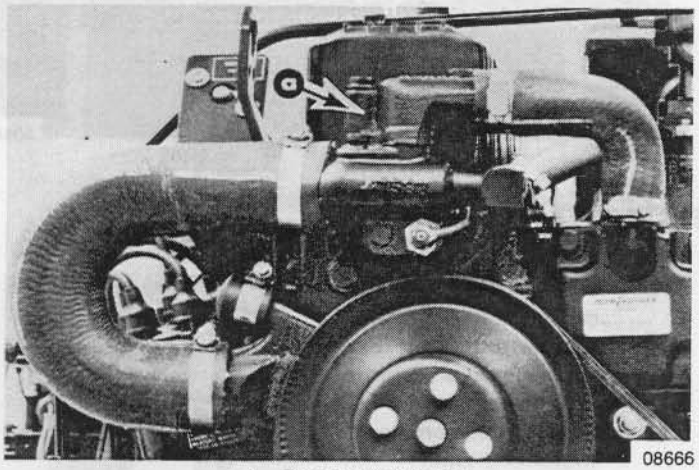


Figure 17. MerCruiser V-Drive Models 330/350 with Closed Cooling

THERMOSTAT

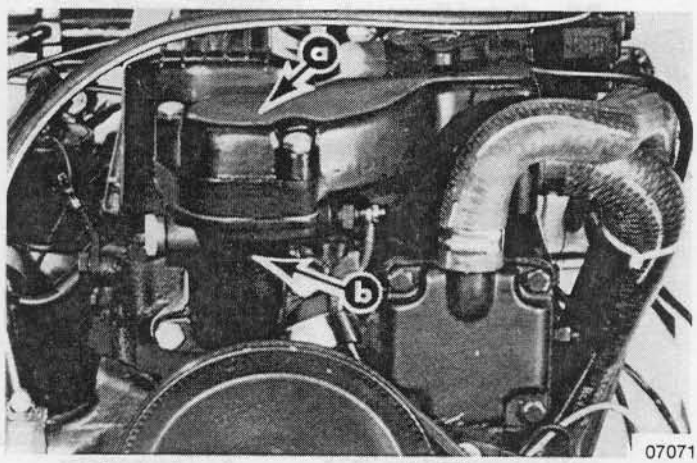
Removal (Locations Shown in Figures 1-thru-7)

1. Drain water or coolant from engine cylinder block and exhaust manifold(s). (Refer to "Draining Instructions", following, for drain locations.)



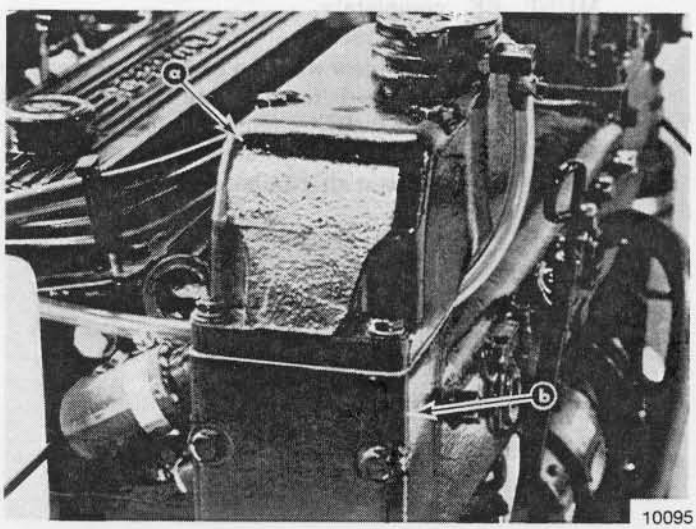
a - Thermostat Cover

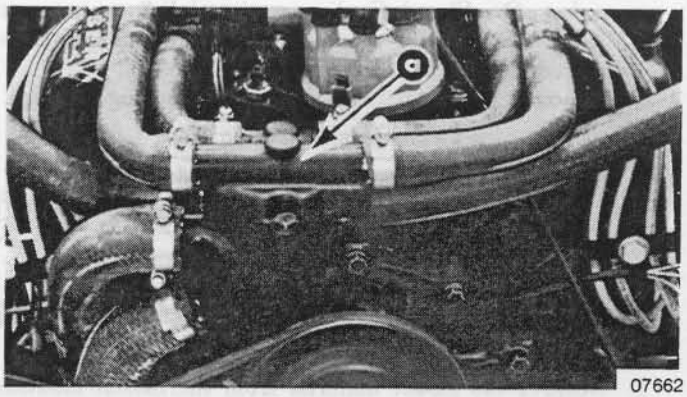
Figure 1. Thermostat Location - MerCruiser 120/140/ 165 with Standard Cooling



a - Reservoir b - Thermostat Housing

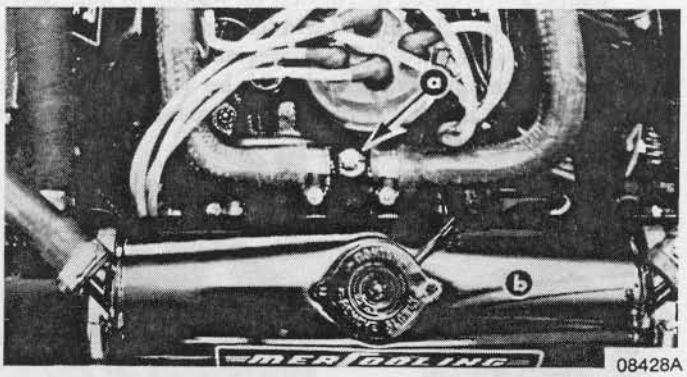
Figure 2. Thermostat Location - MerCruiser 120/140/ 165 with Closed Cooling





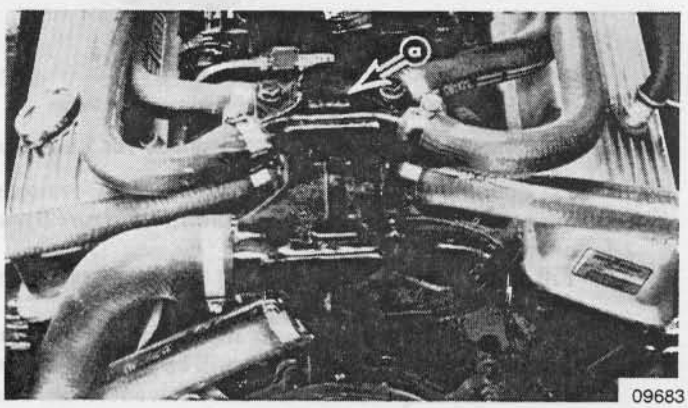
a - Thermostat Cover

Figure 4. Thermostat Location - MerCruiser V-8 Engines with "Ford" Block and Standard Cooling



a - Thermostat Cover b - Heat Exchanger

Figure 5. Thermostat Location - MerCruiser V-8 Engines with "Ford" Block and Closed Cooling



a - Thermostat Housing Cover

Figure 6. Thermostat Location - MerCruiser V-8 Engines with "GM" Block and Standard Cooling

2. On Closed Cooling Equipped V-8 Engines with "Ford" Blocks Only: Remove heat exchanger to gain access to thermostat cover.

a - Reservoir b - Thermostat Housing and Distribution Block

Figure 3. Thermostat Location - MerCruiser 470

3. Disconnect hose(s) from thermostat cover or reservoir. (Reservoir serves as thermostat cover on Closed Cooling equipped in-line engines.)
4. Remove thermostat cover (or reservoir) attaching bolts and lockwashers, then remove cover (or reservoir) and gasket. On Closed Cooling equipped V-8 engines with "GM" blocks, also remove thermostat retaining sleeve and cork gasket. [Discard gasket(s).]
5. Remove thermostat from thermostat housing or cover.

a - Thermostat Housing Cover

Figure 7. Thermostat Location - MerCruiser V-8 Engines with "GM" Block and Closed Cooling

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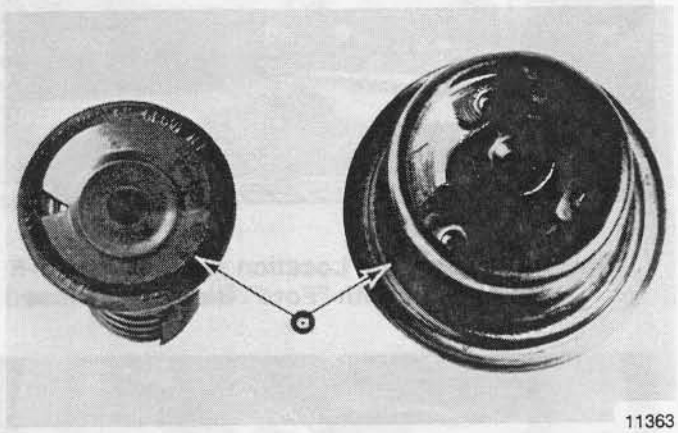
Cleaning/Inspection/Testing

1. Remove old gasket material from thermostat mounting flange with gasket scraper. Clean thermostat in soap and water to remove any deposits or debris.
2. Inspect thermostat for corrosion or other visible damage.
3. If thermostat is suspected of producing insufficient engine temperature, check thermostat for leakage by holding it up to a lighted background. Light leakage around the thermostat valve (Figure 8) indicates that thermostat is not closing completely and should be replaced. (A small amount of leakage at one or 2 points around the valve perimeter is acceptable.)



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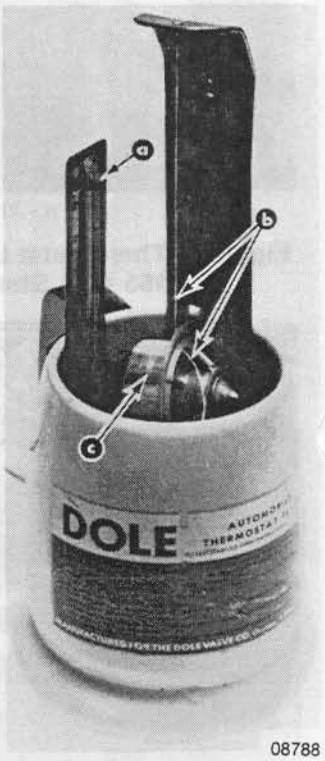
a - Check for Light Leakage around Perimeter of Valve

Figure 8. Checking Typical Thermostats for Leakage

4. Check opening and closing temperature of thermostat (using a tester similar to the one shown in Figure 9), as follows:
   a. Fill tester to within 1" (25.4mm) of top with tap water. DO NOT use distilled water.
   b. Open thermostat valve and insert thread. Position thermostat on thread so that it will be just below water level when suspended, then allow valve to close. Suspend thermostat in water.
   c. Place thermometer in container and position so that bottom of thermometer is even with bottom of thermostat. DO NOT allow thermometer to touch container.

   IMPORTANT: When performing Steps d-thru-f, water MUST BE agitated thoroughly to obtain accurate results.

   d. Plug in tester and observe temperature at which thermostat opens (thermostat drops off thread). Thermostat MUST open at specified temperature stamped on thermostat [160°F (71°C) for MerCruiser 470 thermostats; 143°F (62°C) for all others].
   e. Continue to heat water until a temperature 25°F above temperature specified on thermostat is obtained. Thermostat valve MUST BE completely open at this temperature.



08788

a - Thermometer
b - Nylon String
c - Thermostat

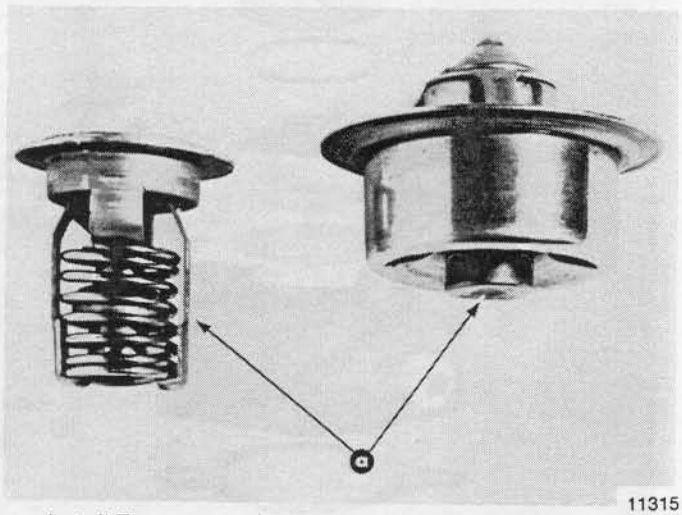
Figure 9. Thermostat Tester

   f. Unplug tester and allow water to cool to a temperature 10°F below specified temperature on thermostat. Thermostat MUST BE completely closed at this temperature.
   g. Replace a thermostat that fails to meet all of the preceding tests.

Thermostat Installation

MERCRUISER 120, 140, 165 and V-8 ENGINES with STANDARD COOLING

1. Clean gasket surfaces on thermostat cover and thermostat housing.
2. On V-8 engines with "GM" blocks only: If thermostat housing was disturbed during removal of thermostat, remove thermostat housing and replace thermostat housing to intake manifold gasket. Before installing, coat both sides of new gasket with Perfect Seal (C-92-34227).
3. Place thermostat in thermostat housing with thermostatic element end toward housing. (Figure 10) Be sure to position thermostat so that mounting flange fits into recess in thermostat housing.



a - Install Thermostat with This End toward Thermostat Housing

Figure 10. Typical Thermostat Installation

4. Coat both sides of new thermostat cover to thermostat housing gasket with Perfect Seal (C-92-34227) and position on thermostat housing. Reinstall thermostat cover and torque bolts as follows:

   MerCruiser 120, 140, 165 and V-8 engines with "GM" blocks - 30 ft. lbs. (4.1mkg)
   MerCruiser V-8 engines with "Ford" blocks - 15 ft. lbs. (2.0mkg)

5. Reconnect hose(s) to thermostat cover.
6. Start engine and inspect for leaks.

MERCRUISER 120, 140, 165 and 470 with CLOSED COOLING

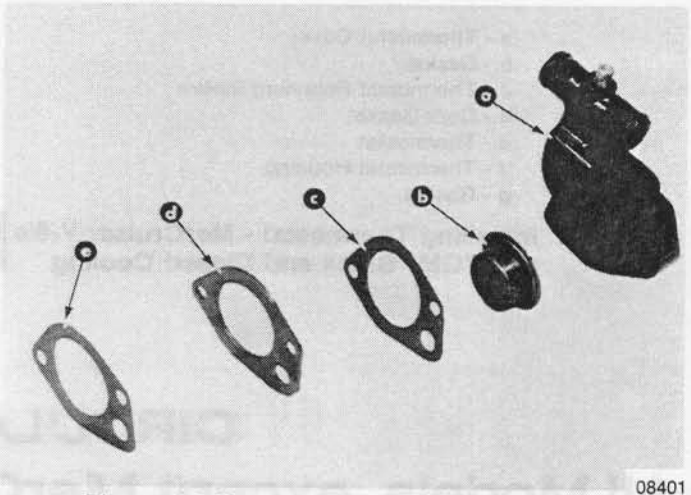
1. Clean gasket surfaces on reservoir and thermostat housing.
2. Place thermostat in thermostat housing with thermostatic element end toward housing. (Figure 10) Be sure to position thermostat so that mounting flange fits into recess in thermostat housing.
3. Coat both sides of new reservoir to thermostat housing gasket with Perfect Seal (C-92-34227) and position on thermostat housing. Reinstall reservoir and torque bolts as follows:

   MerCruiser 120, 140 and 165 - 30 ft. lbs. (4.1mkg)
   MerCruiser 470 - 10 ft. lbs. (1.4mkg)

4. Reconnect hose(s) to thermostat cover.
5. Fill Closed Cooling System with coolant, as outlined under "Filling Instructions - Closed Cooling System" in this section (see "Index").
6. Start engine and inspect for leaks.

MERCRUISER V-8 ENGINES with "FORD" BLOCK and CLOSED COOLING

1. If engine is equipped with a thermostat cover spacer plate (Figure 11), remove plate and plate to intake manifold gasket. Discard gasket.
2. Clean gasket surfaces on thermostat cover, intake manifold and spacer plate (if used).
3. Place thermostat into recess in thermostat cover, as shown in Figure 11.
4. Coat both sides of new thermostat cover gasket(s) with Perfect Seal (C-92-34227), then position gasket, spacer plate (if used) and second gasket (required only if spacer is used) on thermostat cover. (Figure 11) Be sure that holes in gaskets and plate align with holes in thermostat cover.



a - Thermostat Cover
b - Thermostat
c - Gasket
d - Spacer Plate (if Used)
e - Gasket (Required if Spacer Is Used)

Figure 11. Installing Thermostat - MerCruiser V-8's with "Ford" Block and Closed Cooling

IMPORTANT: Be sure that thermostat remains seated in thermostat cover recess (in next step), or coolant leakage will result during operation.

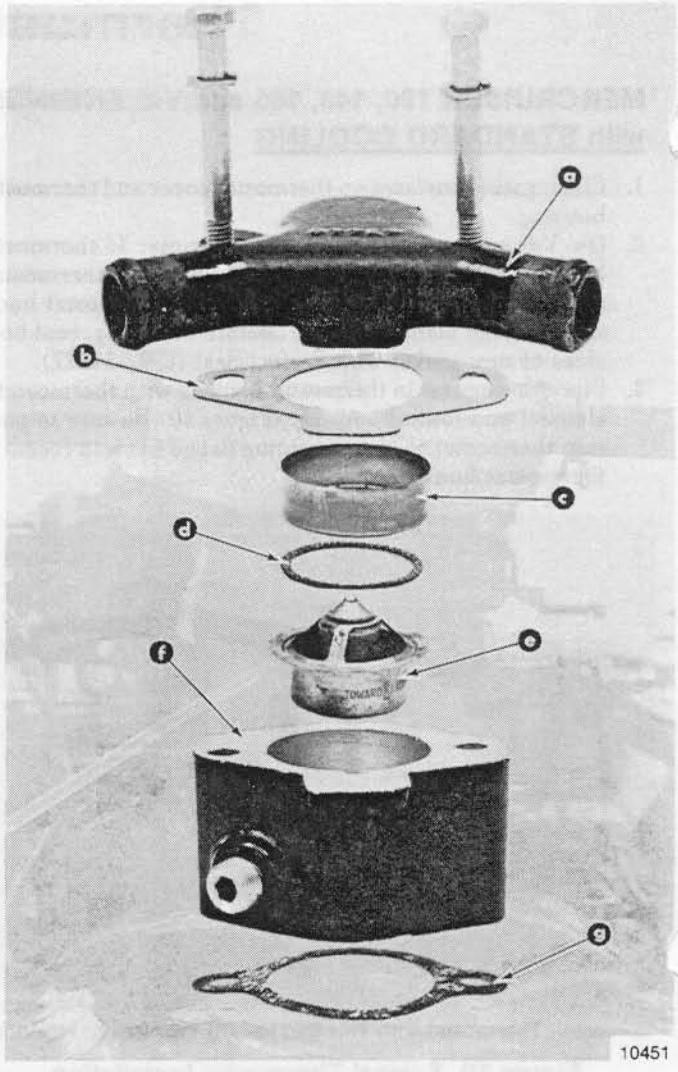
5. Reinstall thermostat cover (with thermostat, gaskets and plate in place) on intake manifold. Torque bolts to 15 ft. lbs. (2.0mkg).
6. Reconnect hoses to thermostat cover.
7. Reinstall heat exchanger on engine and reconnect hoses.
8. Refill Closed Cooling System with coolant, as outlined under "Filling Instructions - Closed Cooling System", in this section (see "Index").
9. Start engine and inspect for leaks.

MERCRUISER V-8 ENGINES with "GM" BLOCK and CLOSED COOLING

1. Remove thermostat housing and thermostat housing to intake manifold gasket. Discard gasket.
2. Clean gasket surfaces on thermostat cover, thermostat housing and intake manifold.

3. Coat both sides of new thermostat housing to intake manifold gasket with Perfect Seal (C-92-34227), then position gasket and thermostat housing on manifold. (Figure 12)
4. Place thermostat, new cork gasket and retaining sleeve in thermostat housing, as shown in Figure 12. Be sure to install retaining sleeve with rolled-over edge downward.
5. Coat both sides of new thermostat cover gasket with Perfect Seal, then position gasket on thermostat housing and reinstall thermostat cover. Torque bolts to 30 ft. lbs. (4.1mkg).
6. Reconnect hoses to thermostat cover.
7. Refill Closed Cooling System with coolant, as outlined under "Filling Instructions - Closed Cooling System" in this section (see "Index").
8. Start engine and inspect for leaks.

NOTE: On engines with 454 cu. in. "GM" block, thermostat housing and cover will be reversed.



a - Thermostat Cover
b - Gasket
c - Thermostat Retaining Sleeve
d - Cork Gasket
e - Thermostat
f - Thermostat Housing
g - Gasket

Figure 12. Installing Thermostat - MerCruiser V-8's with "GM" Block and Closed Cooling

CIRCULATING PUMP

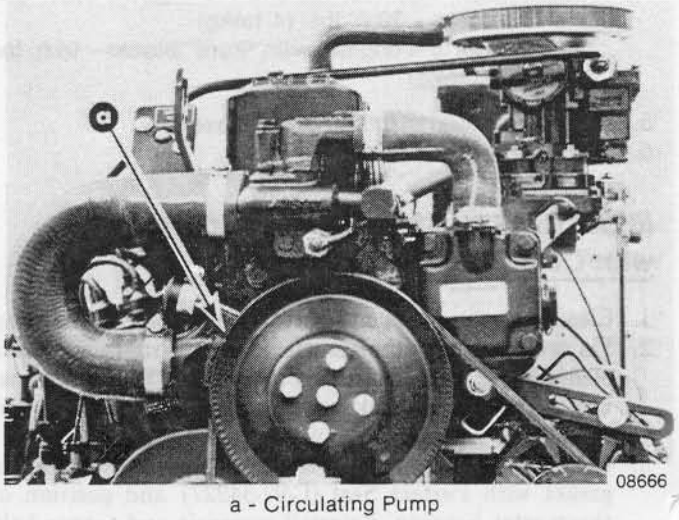
All Models, except MerCruiser 470 (Figure 1, 2 or 3)

REMOVAL

1. Drain water or coolant from cylinder block in accordance with "Draining Instructions" in this section. (See "Index".)
2. Break loose circulating pump pulley attaching bolts. DO NOT remove bolts at this time.
3. Loosen alternator brace attaching bolts and alternator mounting bolt, then pivot alternator inward and remove drive belt.
4. Remove pump pulley attaching bolts, lockwashers, clamping ring (if so equipped) and pulley.
5. Disconnect hose(s) from pump.
6. Remove bolts, which secure pump to cylinder block, and remove pump and old gasket. (Discard gasket.)

CLEANING and INSPECTION

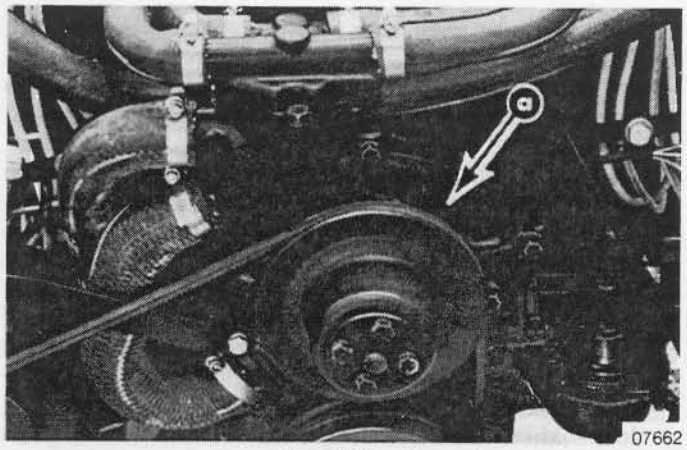
1. Clean gasket surfaces on water pump and cylinder block.
2. Inspect water pump for blockage, cracks, sand holes, corrosion or other damage. Inspect pump impeller for cracks and erosion. Replace complete pump, if any damage exists.
3. Check impeller shaft and bearings for excessive side play. If play can be felt, replace complete pump.



a - Circulating Pump

Figure 1. Circulating Pump Location - MerCruiser 120/140/165

4. Inspect pump pulley for bends, cracks, corrosion or other physical damage. Inspect pulley for rotational trueness. Replace pulley if damaged or untrue.



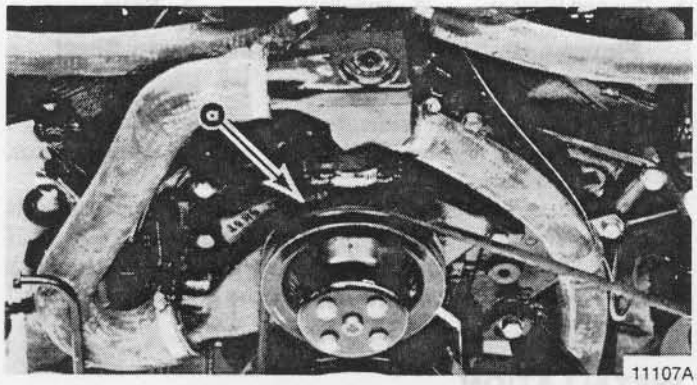
a - Circulating Pump

Figure 2. Circulating Pump Location - MerCruiser V-8 Engines with "Ford" Blocks

5. Inspect circulating pump and alternator drive belt for excessive wear, cracks, fraying or glazed surfaces. Replace belt if any of these exist.

INSTALLATION

1. Coat both sides of new circulating pump gasket with Perfect Seal (C-92-34227), then position gasket and circulating pump on cylinder block. Coat threads of circulating pump attaching bolts with Perfect Seal and install bolts and alternator brace (if applicable). Torque bolts to specifications given in Section 8 (see "Index").
2. Reconnect hose(s) to pump.
3. Install pump pulley and clamping ring (if used) on pump hub and secure with bolts and lockwashers. [Tighten bolts (hand-tight only) at this time.]
4. Install drive belt on pulleys and adjust tension as follows:
   a. Pivot alternator away from engine, as required, until a reading of 65 to 95 lbs. (29.5 to 43.1kg) is obtained on a strand tension gauge at point midway between circulating pump pulley and alternator pulley. (Set a new belt at high reading.) If strand tension gauge is not available, adjust tension so that upper strand of belt can be depressed ½" (12.7mm) with thumb pressure at same point.
   b. After obtaining correct tension, securely retighten alternator brace attaching bolts and alternator mounting bolt.
5. Tighten circulating pump pulley attaching bolts securely.
6. If engine is equipped with Closed Cooling, fill fresh water section with coolant in accordance with "Filling Instructions - Closed Cooling System" in this section (see "Index").
7. Start engine and check for leaks.



a - Circulating Pump

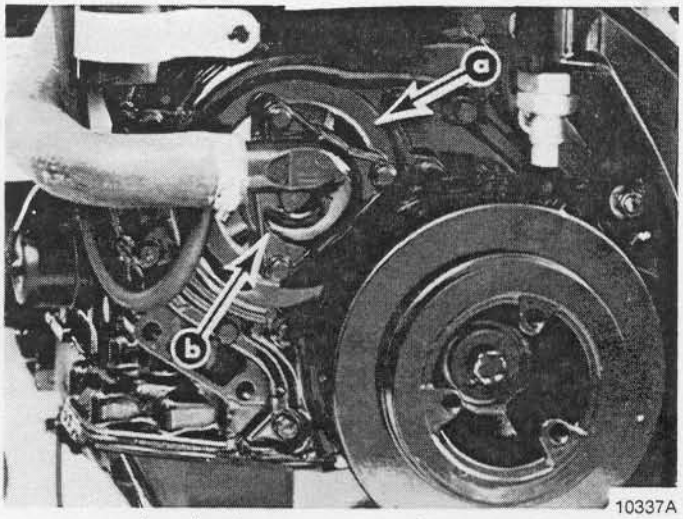
Figure 3. Circulating Pump Location - MerCruiser V-8 Engines with "GM" Blocks

MerCruiser 470 (Figure 4)

REMOVAL

1. Drain fresh water section of closed cooling system in accordance with "Draining Instructions" in this section (see "Index").
2. Engines with pyramid type front engine mount only: Support engine with an overhead hoist and remove front engine mount and mount bracket assembly to gain access to rotor.
3. Remove alternator rotor and stator, as outlined in Section 5D of Service Manual (see "Index").
4. Disconnect hose from inlet connection on front of pump.
5. Remove bolts and lockwashers, which secure impeller cover to front cover, and remove impeller cover and old gasket. Discard gasket.
6. Remove impeller nut by turning in a clockwise direction (nut is left-hand thread), then remove washer, shim and impeller. (Figure 5)
7. Unthread circulating pump shaft from cam shaft by turning in a clockwise direction and remove shaft from front cover. (Figure 5)
8. If oil seals require replacement, remove seals from front cover with Slide Hammer Puller (C-91-34569A1).

NOTE: If front cover is damaged and requires replacement, remove old cover and install new one in accordance with instructions in Section 5D (see "Index").

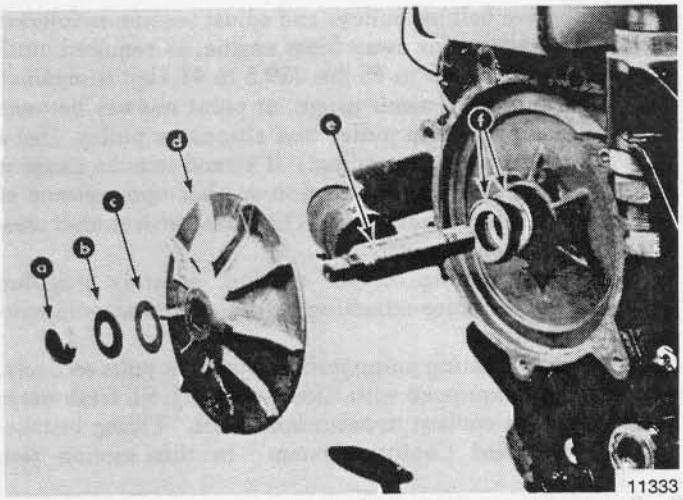


a - Impeller Cover b - Circulating Pump

Figure 4. Circulating Pump Location - MerCruiser 470

CLEANING and INSPECTION

1. Clean gasket surfaces on impeller cover and front cover.
2. Inspect front cover and impeller cover for cracks, sand holes, corrosion or other damage.
3. Inspect impeller for cracks and erosion.



a - Nut
b - Cupped Washer
c - Shim Washer
d - Impeller
e - Impeller Shaft
f - Seals

Figure 5. Impeller and Circulating Pump Shaft Removed

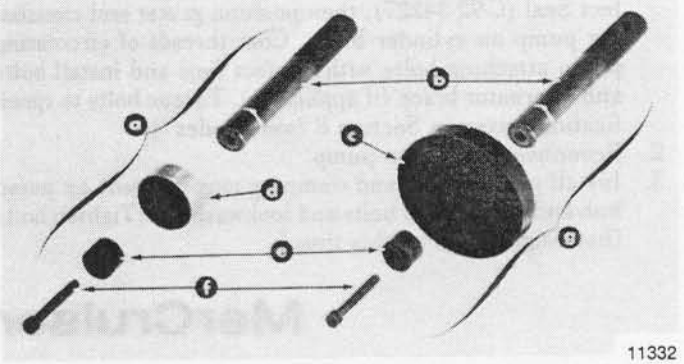
4. Inspect oil seals for wear, tears, roughness, flat spots and proper spring tension. If oil seal serviceability is doubtful, replace seals.
5. Inspect surface of circulating pump shaft (where oil seals contact shaft) for burrs, pitting, nicks or grooves. If possible, clean up damaged surface with No. 320 grit polish cloth and engine oil. If damage is too great, replace shaft and seals.

INSTALLATION

1. Apply Perfect Seal (C-92-34227) to outside diameter of 2 new circulating pump oil seals. DO NOT allow sealer on lips of seals.

CAUTION: When installing seals in next step, DO NOT apply excessive pressure to driver after it bottoms out, as damage to front cover could result.

2. Install seals (with lips pointing outward) into front cover, using seal driver tool from Owatonna Tools Inc., shown in Figure 6, or similar tools. Install first seal in until it bottoms; second seal in until it is flush with cover surface.
3. Fill cavity between seals with U-Joint Lubricant [from U-Joint Grease Kit (C-91-74057A1)], then insert circulating pump shaft through seals and thread into camshaft in a counterclockwise direction. (Figure 5) Tighten shaft securely.
4. Install impeller, shim washer, cupped washer and nut on shaft (in that order) with shim washer positioned on large diameter of shaft and cupped washer installed with concave (hollowed) side toward impeller. (Figure 5) (Use grease, if necessary, to hold shim washer in position.) Torque nut to specification given in Section 8 (see "Index").
5. Apply Perfect Seal to both sides of new impeller cover gasket and to threads of cover attaching bolts, then position gasket on front cover and install impeller cover, lockwashers and bolts. Torque bolts to specification given in Section 8 (see "Index").
6. Reinstall alternator stator and rotor, as outlined in instructions in Section 5D ("Index").
7. Reconnect hose to circulating pump inlet connection.
8. Reinstall front engine mount and mount bracket (if applicable).
9. Fill fresh water section of cooling system with coolant, as outlined under "Filling Instructions - Closed Cooling Systems" in this section ("Index").
10. Start engine and check for leaks.



a - Use This Arrangement to Install First Seal
b - Handle (Owatonna Tool No. 27487)
c - Disc - 3-1/4" (83mm) (27535)
d - Disc - 1-1/2" (38mm) (27507)
e - Disc - 13/16" (21mm) (27496)
f - Screw (10854)
g - Use This Arrangement to Install Second Seal

Figure 6. Seal Driver Tool Assembly (from Owatonna Tools Inc.)

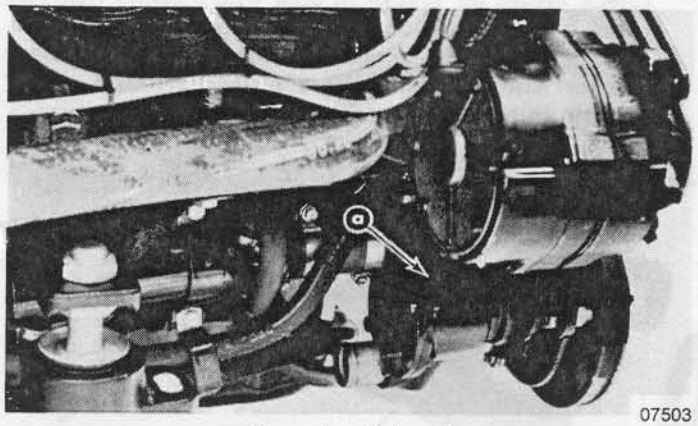
SEAWATER PICKUP PUMP
All I-Drive Engines
(except V-8 Engines with Closed Cooling)

The seawater pickup pump, used on MerCruiser I-Drive Models (except V-8 models equipped with Closed Cooling), is located in the stern drive gear housing. Gear housing must be removed to service pump. Refer to Section 6-A for removal, servicing and installation of pump. (See "Index".)

All V-8 Engines
(except I-Drive Engines with Standard Cooling)

REMOVAL (See Figure 1 or 2 for Pump Location)

CAUTION: If boat is in water when removing seawater inlet hose (in next step), either plug hose or raise it above water level to prevent water from entering boat.



a - Seawater Pickup Pump

Figure 1. Seawater Pickup Pump Location - MerCruiser Models with "Ford" Blocks

1. Remove hose clamps and inlet and outlet hoses from aft end of pump.
2. Break loose 4 bolts which secure seawater pickup pump pulley to pulley hub. DO NOT remove bolts.
3. Loosen seawater pickup pump brace bolts and mounting bracket attaching bolt(s), then pivot pump inward and remove drive belt.
4. Remove 4 bolts (loosened in Step 2), lockwashers and clamping ring (if so equipped), which secure pump pulley to pulley hub, and remove pulley.

   NOTE: On some installations, seawater pickup pump now can be removed by loosening pump mounting bracket clamping bolt and sliding pump out of bracket. If installation does not have sufficient clearance to allow removal in this manner, both mounting bracket and pump must be removed, as explained, following.

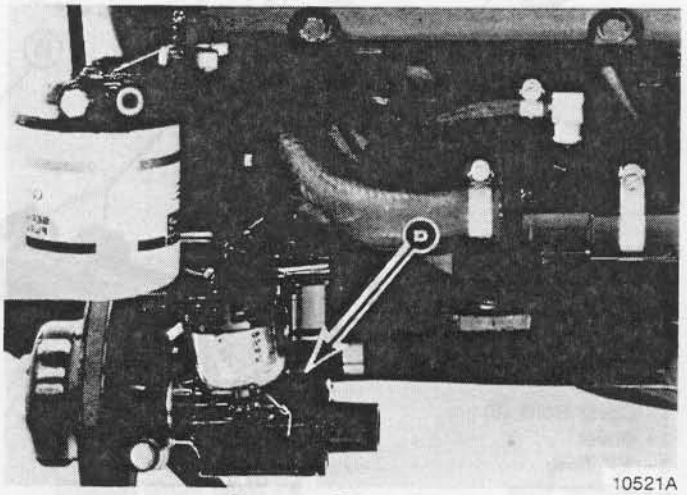
5. Remove pump and mounting bracket assembly, as follows (using "a" or "b"); [refer to Section 1, "Engine Identification", to determine engine block make ("Ford" or "GM") of desired model]:
   a. MerCruiser models with "Ford" blocks - remove bolt, washer(s), and nut which secure adjusting brace to pump mounting bracket. Remove bolt, spacer, washer and nut, which secure pump mounting bracket to alternator bracket, and remove pump and mounting bracket assembly.
   b. MerCruiser models with "GM" blocks - remove bolt, washer(s) and nut which secure adjusting brace to pump mounting bracket. Remove 2 bolts, lockwashers and flat washer, which secure mounting bracket to engine, and remove pump and mounting bracket assembly.
6. Loosen mounting bracket clamping bolt and remove bracket from pump.

OVERHAUL (PUMP B-46-63450A__ and B-46-73823A__)

NOTE: The following instructions are for complete disassembly and overhaul of pump. In many cases, however, complete disassembly of pump is not required and, in those cases, it is necessary only to perform the operations which are required to repair or replace the faulty part.

Disassembly (Refer to Figure 3)

1. Remove 6 hex head bolts, which secure pump cover to pump housing, and remove cover and "O" ring.
2. Remove rubber plug from end of impeller, then pry impeller from pump housing with 2 screwdrivers. Remove 2 impeller drive keys from shaft.



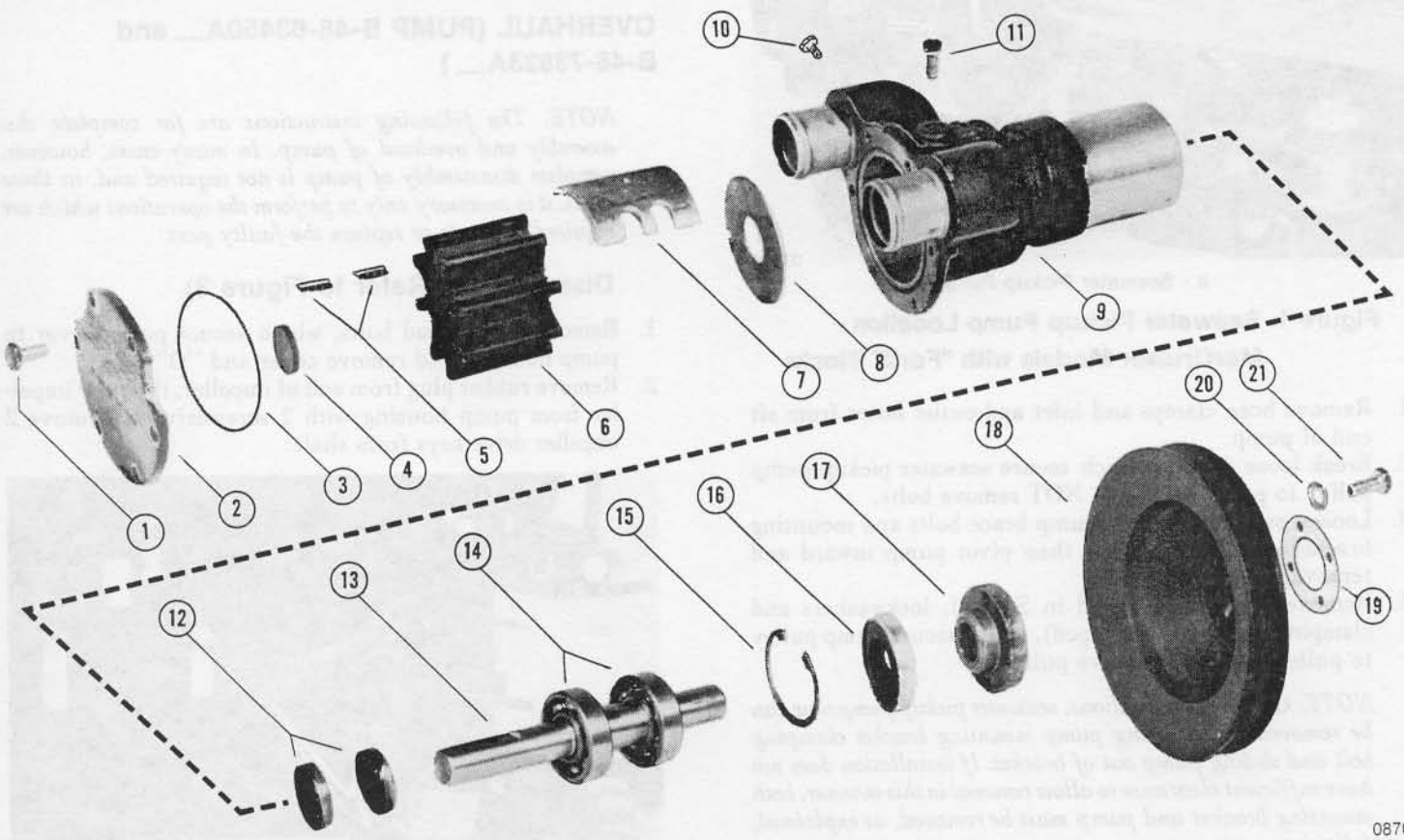
a - Seawater Pickup Pump

Figure 2. Seawater Pickup Pump Location - MerCruiser Models with "GM" Blocks

3. Remove screw, which secures cam segment to pump housing, and remove cam segment and wear plate.
4. Press pulley hub off shaft with Universal Puller Plate (C-91-37241) or equivalent and an arbor press.
5. Puncture front seal with a screwdriver or scratch awl and pry from pump housing. Discard seal.
6. Remove snap ring from pump housing bore and press shaft and bearings out pulley end of housing.
7. Remove bearings from shaft with Universal Joint Puller plate or equivalent and an arbor press. Be sure not to press on outer race.
8. If oil seals require replacement, press 2 rear seals from housing, using an appropriate tool. Discard seals.

Cleaning and Inspection

1. Clean metal parts in solvent and dry with compressed air. If seals are still in pump housing, do not allow solvent to remain on seals for any length of time, as seals could be damaged. When drying bearings with compressed air, do not spin outer races at high speed, as damage to bearings may result.
2. After cleaning, apply a coat of light engine oil to shaft and bearings to prevent rust.
3. Clean all traces of sealing compound from seal seating surfaces.
4. Inspect pump housing for cracks. Also inspect area, where impeller contacts housing, for excessive wear and deep grooves. Check surfaces, where bearings contact housing, for evidence of outer races turning in bearing bore. If bearings have been turning, complete seawater pickup pump assembly must be replaced. Pump housing is not available separately.
5. Inspect seals in water pump housing for wear, flat spots, cuts or roughness. Also check spring within seals for proper tension and positioning. If seal condition is doubtful, replace seal(s).
6. Inspect pump cover, cam segment and wear plate for cracks, deep grooves, excessive wear and warping.
7. Inspect pump shaft bearings for pitting, flat spots, grooves, scoring, discoloration (due to overheating) and embedded foreign material. Also, check bearings by holding inner race and turning outer race. Bearings should turn freely with little-or-no side or end play. If bearing condition is doubtful, replace bearing(s).
8. Inspect pump shaft for grooves in surface where seals contact shaft. If grooves exist, replace both shaft and seals. Inspect keyway in shaft for excessive wear. Also inspect surface, where bearings contact shaft, for evidence of inner bearing races turning on shaft. If bearings have been turning on shaft, replace shaft.
9. Inspect impeller drive keys for excessive wear.
10. Inspect pump impeller for wear on sides of tips of blades. Check blades for cracks in area where blades flex, also check for cracks in bonding between impeller and hub. Replace impeller if excessively worn or if any cracks are present. Also replace impeller if blades have taken a "set" (remain in curved position).



1 - Cover Bolts (6)
2 - Cover
3 - "O" Ring
4 - Rubber Plug
5 - Impeller Drive Keys (2)
6 - Impeller
7 - Cam Segment
8 - Wear Plate
9 - Water Pump Housing
10 - Pipe Plug
11 - Cam Segment Screw
12 - Oil Seals (Rear)
13 - Shaft
14 - Ball Bearings
15 - Snap Ring
16 - Oil Seal (Front)
17 - Pulley Hub
18 - Pulley
19 - Clamping Ring (If so Equipped)
20 - Lockwashers (4)
21 - Pulley Bolts (4)

Figure 3. Seawater Pickup Pump B-46-63450A__ and B-46-73823A__, Exploded Parts View

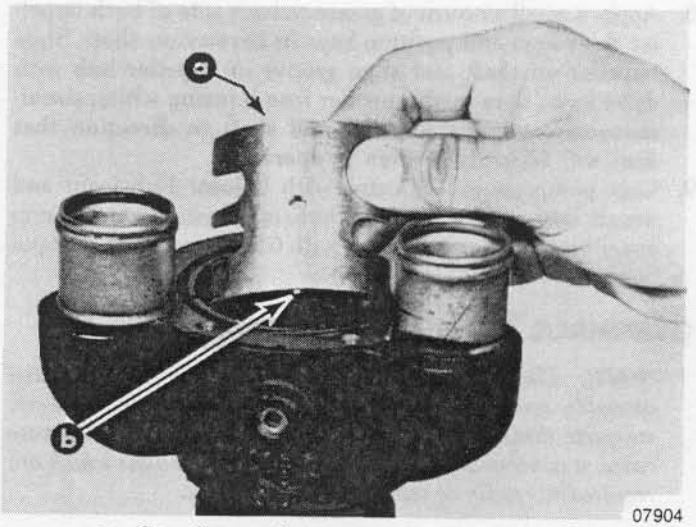
11. Inspect pump pulley for bends or warping and replace if present. Pulley MUST BE perfectly true (cannot wobble) when installed, or damage to the pump and drive belt may result. Also, inspect pulley sheaves for pitting, nicks, burrs and corrosion. Repair damaged surfaces, if possible, using a fine file and a wire brush, or replace pulley if damaged beyond repair. Pulley sheaves must be smooth, or drive belt wear will be greatly accelerated.
12. Check drive belt for excessive wear (belt bottoms in pulley), fraying, glazing, cracks or other signs of deterioration. If belt condition is doubtful, replace belt.

Reassembly (Refer to Figure 3)

1. Apply a thin coat of Loctite Type "A" (C-92-32609) to outside diameter of 2 new pump housing rear seals, then install seals in housing with seal lips facing impeller end. (Press first seal in until it bottoms-out and second seal is flush with pump housing.)

IMPORTANT: It is recommended that Shell Alvania No. 3 Grease be used when packing seals and bearings in the following steps. If Shell Alvania No. 3 Grease is not available, it is permissible to use U-Joint Lubricant [from U-Joint Grease Kit (C-91-74057A1)]. However, U-Joint Lubricant is not recommended for applications where continuous high-speed heavy-duty operation will be encountered.

2. Pack cavity between seals with Shell Alvania No. 3 Grease or equivalent.
3. Press ball bearings onto shaft until they seat. Be sure to press on inner race of bearings only.
4. Pack bearings and cavity between bearings with Shell Alvania No. 3 Grease, then slide bearings and shaft into pump housing bore and install snap ring.



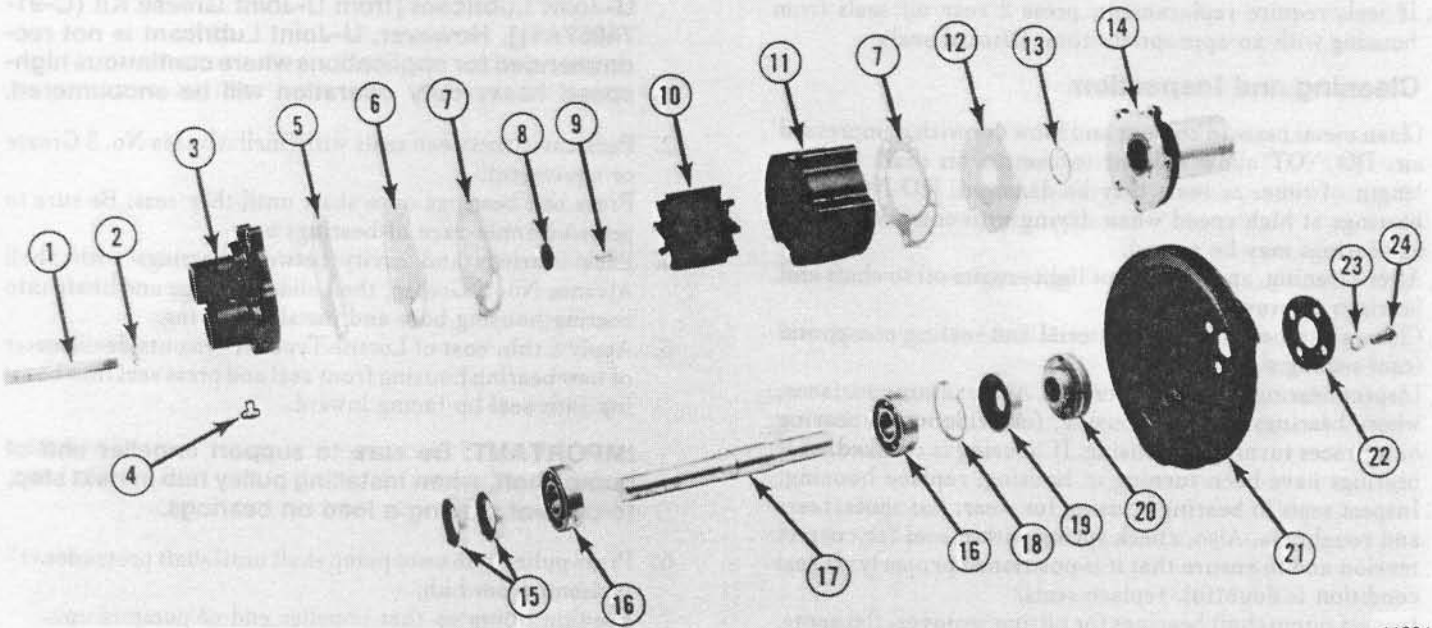
a - Cam Segment b - Pin

Figure 4. Installing Cam Segment

5. Apply a thin coat of Loctite Type "A" to outside diameter of new pump housing front seal, then press seal into housing with seal lips pointing inward.

IMPORTANT: Be sure to support impeller end of pump shaft when installing pulley hub (in next step), to prevent placing a load on bearings.

6. Press pulley hub onto pump shaft so that end of shaft protrudes ¼" (6.4mm) from hub.
7. Apply a thin film of silicone sealer to back side of wear plate and cam segment, then install wear plate and cam segment in water pump housing. Cam segment must be installed so that pin aligns with recess in pump housing, as shown in Figure 4. Secure cam segment with screw and torque to 24 in. lbs. (28kg-cm).



1 - Cover Bolts (5)
2 - Washers, Cover Bolt (5)
3 - Cover
4 - Pipe Plug
5 - Gasket (Cover to Outer Wear Plate)
6 - Outer Wear Plate
7 - Gasket (Wear Plate to Pump Body)
8 - Rubber Plug
9 - Impeller Drive Key
10 - Impeller
11 - Pump Body
12 - Inner Wear Plate
13 - "O" Ring
14 - Bearing Housing
15 - Oi Seals (Rear)
16 - Ball Bearings (2)
17 - Pump Shaft
18 - Snap Ring
19 - Oil Seal (Front)
20 - Pulley Hub
21 - Pulley
22 - Clamping Ring
23 - Lockwashers (4)
24 - Pulley Bolts (4)

Figure 5. Seawater Pickup Pump B-46-72774A__, Exploded Parts View

8. Apply a small amount of grease to back side of both impeller drive keys and position keys in keyway on shaft. Slide impeller on shaft and align groove in impeller hub with drive keys, then push impeller into housing while, simultaneously, turning impeller and shaft in direction that they will be turning when in operation.
9. Coat pump cover "O" ring with U-Joint Lubricant and install into groove in pump housing. Install water pump cover on housing and secure with 6 hex head bolts. Torque bolts to 60 in. lbs. (69kg-cm).

OVERHAUL (PUMP B-46-72774A__)

NOTE: The following instructions are for complete disassembly and overhaul of pump. In many cases, however, complete disassembly of pump is not required and, in those cases, it is necessary only to perform the operations which are required to repair or replace the faulty part.

Disassembly (Refer to Figure 5)

1. Remove 5 bolts and washers which secure pump cover to pump, then remove cover, cover to outer wear plate gasket, wear plate and wear plate to pump body gasket. Discard gaskets.
2. Slide impeller and pump body off shaft. Remove impeller from pump body and rubber plug from impeller.
3. Remove impeller drive key from pump shaft, then remove pump body to inner wear plate gasket, inner wear plate and "O" ring. Discard gasket and "O" ring.
4. Press pulley hub off shaft with Universal Puller Plate (C-91-37241) and an arbor press.
5. Puncture front oil seal with a screwdriver or similar tool and pry from bearing housing.
6. Remove snap ring from bearing housing bore and press shaft and bearings out pulley end of housing.
7. Remove bearings from shaft with Universal Puller Plate or equivalent and an arbor press. DO NOT press on outer race, or bearing may be damaged.
8. If seals require replacement, press 2 rear oil seals from housing with an appropriate tool. Discard seals.

Cleaning and Inspection

1. Clean metal parts in solvent and blow dry with compressed air. DO NOT allow solvent to remain on seals for any length of time, as seals may be damaged. DO NOT spin bearings at high speed when drying with compressed air, as bearings may be scored.
2. After cleaning, apply a coat of light engine oil to shaft and bearings to prevent rust.
3. Clean all traces of gasket material and sealing compound from sealing surfaces.
4. Inspect bearing housing for cracks. Also examine surfaces, where bearings contact housing, for evidence of bearing outer races turning in housing. If housing is cracked, or if bearings have been turning in housing, replace housing.
5. Inspect seals in bearing housing for wear, flat spots, tears and roughness. Also, check spring within seal for correct tension and to ensure that it is positioned properly. If seal condition is doubtful, replace seals.
6. Inspect pump shaft bearings for pitting, grooves, flat spots, scoring, discoloration (from overheating) or embedded foreign material. Replace bearing(s) if any of these exist. Also, check bearings by holding inner race and turning outer race. Bearings should turn freely with little-or-no side or end play.
7. Inspect pump shaft for grooves in surface where seals contact shaft. If grooves exist, both shaft and seals must be replaced. Inspect keyway in shaft for wear. Also inspect surface, where bearings contact shaft, for evidence of inner races turning on shaft. If keyway is worn or if bearings have been turning on shaft, replace shaft.
8. Inspect impeller drive key for excessive wear.
9. Inspect pump body for cracks, excessive wear and grooves.
10. Inspect inner and outer wear plate for excessive wear, grooves or warping.
11. Inspect pump impeller for wear on sides and tips of blades. Also inspect blades for cracks in area where blades flex. Check bonding between impeller and impeller hub for cracks. Replace impeller if worn or cracked. Also replace impeller, if blades have taken a set (remain in curved position).
12. Inspect pump pulley for bends or warping and replace if present. Pulley MUST BE perfectly true (cannot wobble) when installed, or damage to the pump and drive belt may result. Also, inspect pulley sheaves for pitting, nicks, burrs and corrosion. Repair damaged surfaces, if possible, using a fine file and a wire brush, or replace pulley if damaged beyond repair. Pulley sheaves must be smooth, or drive belt wear will be greatly accelerated.
13. Check drive belt for excessive wear (belt bottoms in pulley), fraying, glazing, cracks or other signs of deterioration. If belt condition is doubtful, replace belt.

Reassembly (Refer to Figure 5)

1. Apply a thin coat of Loctite Type "A" (C-92-32609) to outside diameter of 2 new bearing housing rear seals, then install seals in housing with seal lips facing impeller end. (Press first seal in until it bottoms-out and second seal in until flush with housing.)

IMPORTANT: It is recommended that Shell Alvania No. 3 Grease be used when packing seals and bearing in the following steps. If Shell Alvania No. 3 Grease is not available, it is permissible to use U-Joint Lubricant [from U-Joint Grease Kit (C-91-74057A1)]. However, U-Joint Lubricant is not recommended for applications where continuous high-speed heavy-duty operation will be encountered.

2. Pack cavity between seals with Shell Alvania No. 3 Grease or equivalent.
3. Press ball bearings onto shaft until they seat. Be sure to press on inner race of bearings only.
4. Pack bearings and cavity between bearings with Shell Alvania No. 3 Grease, then slide bearings and shaft into bearing housing bore and install snap ring.
5. Apply a thin coat of Loctite Type "A" to outside diameter of new bearing housing front seal and press seal into housing with seal lip facing inward.

IMPORTANT: Be sure to support impeller end of pump shaft, when installing pulley hub in next step, to prevent placing a load on bearings.

6. Press pulley hub onto pump shaft until shaft protrudes ¼" (6.4mm) from hub.
7. Position pump so that impeller end of pump is up. Coat "O" ring with U-Joint Lubricant and install into groove in housing.
8. Place inner wear plate on housing and align holes with holes in pump. Coat pump body to wear plate gasket with Perfect Seal (C-92-34227) and position on wear plate.
9. Install impeller into pump body by turning impeller in direction that it will be turning in operation, while simul-

taneously pushing inward. Impeller blades all MUST BE pointed in same direction.

10. Apply a small amount of grease to back side of impeller drive key and position key in keyway on shaft. Align groove in impeller hub with drive key, then slide impeller and pump body assembly onto shaft and position so that holes in pump body align with threaded holes in bearing housing.
11. Coat both sides of new cover to outer wear plate gasket and outer wear plate to pump body gasket with Perfect Seal. Install outer wear plate with new gaskets on each side. Be sure to align holes properly.
12. Install pump cover and secure with 5 bolts and washers. Torque bolts to 10 ft. lbs. (1.38mkg).

PUMP INSTALLATION

NOTE: If pump mounting bracket was not removed during removal of pump, slide pump into bracket and proceed with Step 3.

1. Slide mounting bracket onto pump. DO NOT tighten clamping bolt at this time.
2. Reattach pump and mounting bracket assembly to engine, as follows (use "a" or "b"):
   a. MerCruiser models with "Ford" blocks
      1. If removed, install spacer into rear hole in pump mounting bracket until flush with inside surface, then attach pump and mounting bracket assembly to alternator bracket with thru bolt,flat washer and locknut. (Install flat washer between spacer and nut.) Tighten bolt and nut until spacer just contacts alternator bracket. DO NOT fully tighten bolt at this time.
      2. Reconnect brace to pump mounting bracket with bolt, washer(s) and nut. DO NOT tighten bolt at this time.
   b. MerCruiser models with "GM" blocks
      1. Attach pump and mounting bracket assembly to cylinder block with bolts, lockwashers and flat washer. (Install flat washer under lower bolt.) Tighten bolts hand-tight only at this time.
      2. Reconnect adjusting brace to pump mounting bracket with bolt, washer(s) and nut. DO NOT tighten bolt at this time.
3. Install pulley on pump and secure with 4 bolts, lockwashers and clamping ring (if so equipped). Tighten bolts hand-tight only at this time.
4. Move seawater pickup pump fore or aft in mounting bracket, as required, to properly align pump pulley with crankshaft pulley. Also, rotate pump, as required, to align outlet hose connection on back of pump with outlet hose.
5. After pump has been positioned properly, torque mounting bracket clamping bolt to 20 ft. lbs. (2.8mkg).
6. Reconnect inlet and outlet hoses to corresponding connections on aft end of pump and secure with hose clamps.
7. Install drive belt on pump and crankshaft pulleys and adjust tension, as follows:
   a. Pivot pump and mounting bracket assembly away from crankshaft pulley, as required, until a strand tension gauge reading of 65 to 95 lbs. (29-43kg) is obtained when taken at point midway between crankshaft pulley and pump pulley. (Use high value for a new belt.) If strand tension gauge is not available, adjust tension so that upper strand of belt can be depressed ¼" (6.35 mm) with thumb pressure at same point.
   b. After obtaining correct tension, tighten pump mounting bracket and brace attaching bolts securely.
8. Tighten pump pulley attaching bolts (installed in Step 3) securely, using drive belt to help prevent pulley from turning.

CLOSED COOLING SYSTEM PRESSURE TEST

If fresh water section of Closed Cooling System is suspected of leaking or not holding sufficient pressure, and no visible signs of leakage can be found, perform the following test:

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap. Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled off, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

1. Remove pressure cap from heat exchanger or reservoir.
2. Clean, inspect and pressure test pressure cap, as outlined under "Closed Cooling System Maintenance - Pressure Cap" in this section, to eliminate the possibility that cap is not maintaining proper presure in system and is causing coolant to boil over.
3. Clean inside of filler neck to remove any deposits or debris. Examine lower inside sealing surface for nicks or other damage. Surface MUST BE perfectly smooth to achieve a good seal between it and rubber seal on cap. Also, check locking cams on sides of filler neck to be sure that they are not bent or damaged. If locking cams are bent or damaged, pressure cap will not hold the proper pressure.
4. Adjust coolant level in fresh water section to 1" (25.4mm) below filler neck.
5. Attach an automotive-type cooling system pressure tester to filler neck and pressurize fresh water section to 17 psi (1.2kg/cm²).
6. Observe gauge reading for approximately 2 minutes; pressure should not drop during this time. If pressure drops, proceed with the following steps until leakage is found.
7. While maintaining a pressure of 17 psi on fresh water section, visually inspect external portion of cooling system (hoses, gaskets, drain plugs, petcock(s), core plugs, circulating pump seals, etc) for leakage. Also listen closely for bubbling or hissing, as they usually are a sure indication of a leak.
8. Remove seawater outlet hose from heat exchanger. (Refer to "Cooling System Flow Diagrams", if necessary, for hose location.) Repressurize system to 17 psi and observe outlet connection on heat exchanger. If water flows from connection, or if air bubbles are present in water, a leak exists between fresh water section and seawater section of heat exchanger. Also listen for bubbling or hissing, as this is a certain indication of leakage. Reconnect hose if no evidence of leakage is found.
9. If no leakage could be found in above steps, engine is leaking internally, and it probably is due to one or more of the following: 1) Loose cylinder head bolts or damaged gasket, 2) loose intake manifold bolts or damaged gasket (V-8 engines only), 3) loose exhaust elbow or distribution block retaining nuts or damaged gasket (470 Model and V-8 engines only), 4) cracked or porous cylinder head or block, 5) cracked or porous exhaust manifold or intake manifold (470 Model and V-8 engines only), 6) damaged circulating pump seals (470 engine only), 7) cracked or porous front cover (470 Model and V-8 with "Ford" block only). Proceed as follows until location of internal leak is found —
   a. Start engine. Repressurize system to 17 psi and observe pressure gauge on tester. If needle in gauge vibrates, compression or combustion is leaking into fresh water section from a leak in the combustion chamber. Exact cylinder(s), where leakage is taking place, sometimes can be found by removing spark plug wires (one at a time) while observing pressure gauge. Vibration will decrease or stop when spark plug wire is removed from leaking cylinder. Stop engine.
   b. Remove spark plugs (one at a time) from cylinders and examine for presence of coolant. A spark plug, that is perfectly clean or milky appearing, is a sure indication of a leak.
   c. Drain oil from engine and examine for presence of coolant. Oil usually will be milky, if coolant is present. If coolant is present, remove engine from boat and drop the oil pan. With engine in the upright position, repressurize fresh water section to 17 psi and examine internal surfaces of engine to locate leak.
   d. If no leakage can be found in above steps, entire engine must be disassembled and inspected for leakage.

CLOSED COOLING SYSTEM MAINTENANCE

Pressure Cap Maintenance

Pressure cap is designed to maintain a pressure of approximately 14 psi (1kg/cm²) in fresh water section once engine has attained operating temperature. Cap should be cleaned, inspected and pressure-tested at regular tune-up intervals or whenever cap is suspected of maintaining improper pressure, as follows:

SAFETY WARNING: Engine MUST BE cooled down before removing pressure cap (in next step), as sudden loss of pressure could cause coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

1. Carefully remove pressure cap from reservoir or heat exchanger.
2. Wash cap with clean water to remove any deposits or debris from sealing surfaces.
3. Inspect gasket (if used) and rubber seal on cap for tears, cuts, cracks or other signs of deterioration. Replace gasket, if damaged, or entire cap, if rubber seal is damaged.
4. Check that locking tabs on cap are not bent or damaged.
5. Using a cooling system pressure tester (similar to one shown in Figure 1), test cap to be sure that it releases at proper pressure and does not leak. (Refer to instructions which accompany tester for correct test procedure.) Cap MUST relieve pressure between 11 and 17 psi (0.77 and 1.2kg/cm²) and must hold rated pressure for 30 seconds without going below 11 psi. Replace cap if it fails to fall within these limits.

Figure 1. Pressure Testing Pressure Cap

NOTE: Before reinstalling cap in next step, examine lower inside sealing surface in filler neck to ensure that it is perfectly smooth and free of debris. Also, inspect cam lock flanges on sides of filler neck to be sure that they are not bent.

6. Reinstall cap on reservoir or heat exchanger.

Testing Coolant for Alkalinity

Coolant in fresh water section should be replaced once every 2 years and should be tested for alkalinity every other year, as follows:

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

1. Obtain pink litmus paper from local supplier (laboratory, drug store, pet shop, etc).
2. Remove pressure cap (fill cap) from heat exchanger or reservoir and insert one end of litmus paper into coolant.
3. If pink litmus paper turns blue, coolant is alkaline and need not be replaced.
4. If pink litmus paper remains pink, coolant is not alkaline and MUST BE replaced. Drain and refill fresh water section in accordance with "Drain Instructions" and "Filling Instructions - Closed Cooling System", following (see "Index").

Cleaning Fresh Water Section

Fresh water section of Closed Cooling System should be cleaned at least once every 2 years or whenever decreased cooling efficiency is experienced.

A good grade automotive cooling system cleaning solution may be used to remove rust, scale or other foreign material. Manufacturer's instructions, which accompany particular cleaner, always should be followed.

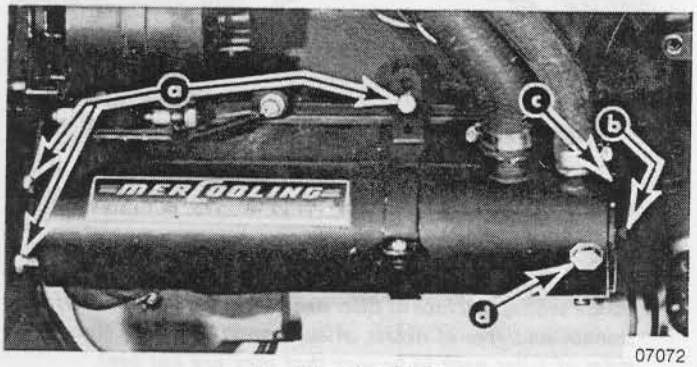
If fresh water section is extremely dirty, a pressure flushing device may be used to flush out remaining deposits. Flushing should be done in direction opposite normal coolant flow to allow water to get behind deposits and force them out. Refer to "Cooling System Flow Diagrams", preceding, and instructions which accompany flushing device for proper hookup and flushing procedure.

Cleaning Seawater Section of Heat Exchanger

Cooling efficiency of an engine with Closed Cooling is greatly dependent upon heat transfer through the tubes within the heat exchanger. During engine operation, contaminants within the seawater (such as salt, silt, lime, etc) collect on the inside of the tubes, thus reducing heat transfer and greatly decreasing heat exchanger efficiency. It is, therefore, recommended that the seawater section of the heat exchanger be cleaned at least once every 2 years or whenever decreased cooling efficiency is suspected, as follows:

MERCRUISER 120, 140 and 165 (Figure 2)

1. Drain seawater and fresh water section of Closed Cooling System as outlined in "Draining Instructions, following.
2. Loosen hose clamps and disconnect all hoses from heat exchanger.



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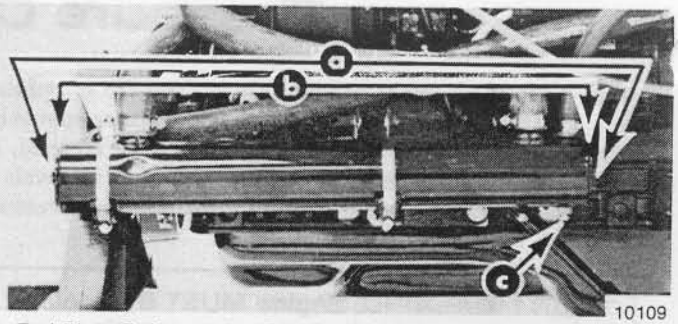
a - Mounting Bolts
b - End Plate Bolt
c - End Plate
d - Zinc Electrode

Figure 2. Cleaning Heat Exchanger - MerCruiser 120/ 140/165

3. Remove 3 bolts, which secure heat exchanger to engine, and remove heat exchanger.
4. Remove bolt, that secures end plate to aft end of heat exchanger, then remove end plate, seal washer and gasket. Discard seal washer and gasket. Clean gasket material from heat exchanger and end plate.
5. Clean water passages in heat exchanger by inserting a suitable-size wire brush into each passage. After deposits have been loosened, hold heat exchanger in vertical position (with end plate end downward) and use compressed air to blow particles out of water passages.
6. If so equipped, remove zinc electrode (shown in Figure 2) from heat exchanger and examine for erosion. Replace electrode, if eroded 25% or more, or reinstall old electrode, if eroded less than 25%. [Coat threads of electrode with Perfect Seal (C-92-34227) before installing.]
7. Apply Perfect Seal to both sides of new end plate gasket, then reinstall end plate, using new gasket and seal washer. (Be sure to install seal washer between end plate and gasket.) Torque end plate bolt to 16 ft. lbs. (2.2mkg).
8. Reinstall heat exchanger on engine. Tighten 3 bolts securely.
9. Reinstall hoses and secure with hose clamps.
10. Fill fresh water section with coolant, as outlined under "Filling Instructions - Closed Cooling Systems", following.
11. Start engine and inspect heat exchanger hose connections and gaskets for leaks.



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a - End Plate Bolts b - End Plates c - Seawater Drain Plug

Figure 3. Cleaning Heat Exchanger - MerCruiser 470

MERCRUISER 470 (Figure 3) and V-8 ENGINES with FRONT MOUNTED CLOSED COOLING SYSTEM (Figure 4)

1. Remove seawater drain plug from bottom of heat exchanger and allow water to drain. After water has drained completely, coat threads of drain plug with Perfect Seal (C-92-34227) and reinstall.
2. Remove bolts, which secure end plates to each end of heat exchanger, then remove end plates, seal washers and gaskets. Discard seal washers and gaskets. Clean gasket material from end plates and heat exchanger.
3. Clean water passages in heat exchanger by inserting a suitable size wire brush into each passage. Use compressed air to blow loose particles out of water passages.
4. On V-8 engines so equipped, remove zinc electrode (shown in Figure 4) from heat exchanger and examine for erosion. Replace electrode, if eroded 25% or more. Reinstall old electrode, if eroded less than 25%. Coat threads of electrode with Perfect Seal before installing.

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a - End Plates c - Seawater Drain Plug
b - End Plate Bolts d - Zinc Electrode (if So Equipped)

Figure 4. Cleaning Heat Exchanger - Typical V-8 Engine with Front-Mounted Closed Cooling

5. Apply Perfect Seal to both sides of new end plate gaskets, then reinstall end plates, using new gaskets and seal washers. (Be sure to install seal washers between end plates and gaskets.) Torque end plate bolts to 16 ft. lbs. (2.2mkg).
6. Start engine and inspect cooling system for leaks.

MERCRUISER V-8 ENGINES with REAR MOUNTED CLOSED COOLING (Figure 5)

1. Drain seawater and fresh water sections of Closed Cooling System, as outlined in "Draining Instructions", following.

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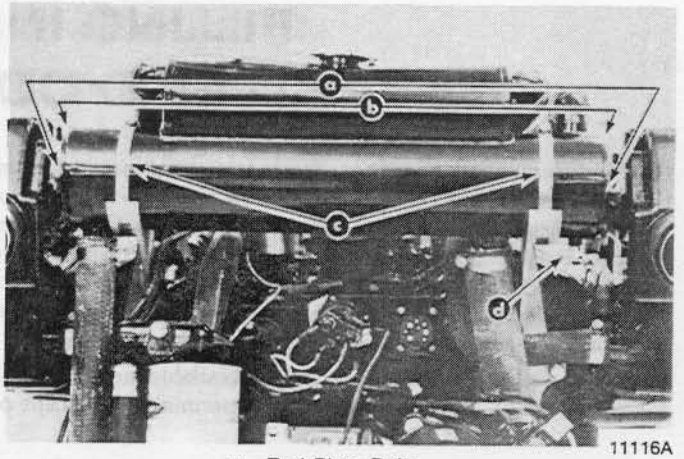
2. Loosen hose clamps and disconnect all hoses from heat exchanger.
3. Remove 2 mounting clamps, that secure heat exchanger to mounting brackets, and remove heat exchanger.
4. Remove bolts, that secure end plates to heat exchanger, then remove end plates, seal washers and gaskets. Discard seal washer and gaskets. Clean gasket material from end plates and heat exchanger.
5. Clean water passages in heat exchanger by inserting a suitable size wire brush into each water passage. Use compressed air to blow loose particles out of water passages.
6. Apply Perfect Seal to both sides of new end plate gaskets, then reinstall end plates, using new gaskets and seal washers. (Be sure to install seal washer between end plates and gaskets.) Torque end plate bolts to 16 ft. lbs. (2.2mkg).
7. Reinstall heat exchanger on mounting brackets and secure with clamps.
8. Reinstall hoses and secure with hose clamps.
9. Fill fresh water section with coolant, as outlined under "Filling Instructions - Closed Cooling Systems", following.
10. Start engine and inspect heat exchanger hose connections and gaskets for leaks.



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a - End Plate Bolts
b - End Plates
c - Mounting Clamps
d - Drain Plug

Figure 5. Cleaning Heat Exchanger - Typical MerCruiser V-8 Engine with Rear Mounted Closed Cooling

FILLING INSTRUCTIONS - CLOSED COOLING SYSTEM

On MerCruiser 470 Engines, fresh water section of Closed Cooling System MUST BE filled with a 50/50 solution of ethylene glycol (anti-freeze) and pure soft water. On all other engines, it is recommended that fresh water section be filled with a solution of ethylene glycol and pure soft water mixed to proportions recommended by manufacturer to protect engine to lowest temperature to which engine will be exposed.

If ethylene glycol (anti-freeze) is not available, and the possibility of freezing does not exist, it is permissible (except on MerCruiser 470) to use a solution of rust inhibitor and pure soft water mixed to manufacturer's recommendations. Fill fresh water section as follows:

NOTE: Refer to "Closed Cooling System Specifications" in Section 8-A for approximate cooling system capacity. (See "Index".)

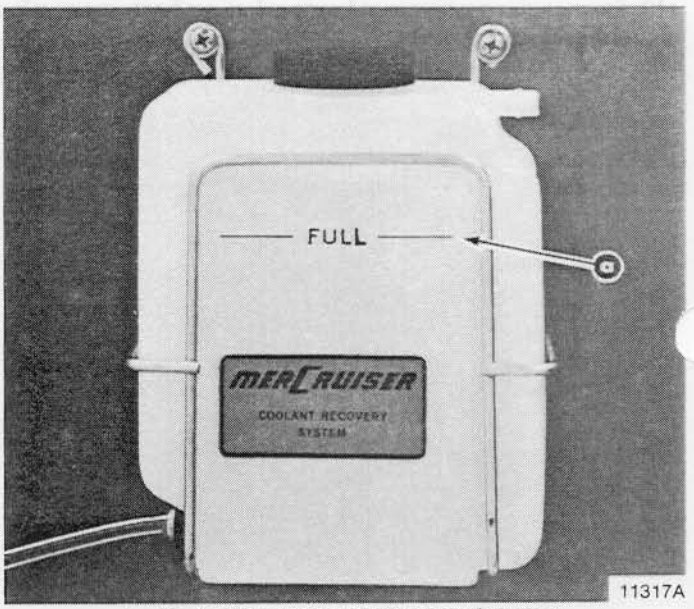
All Engines (except Inboard 198, 228, 255 and 330 with Rear-Mounted Closed Cooling)

1. Remove pressure cap (fill cap) from reservoir or heat exchanger.
2. Fill fresh water section with coolant solution until coolant level reaches top of filler neck.

CAUTION: DO NOT operate engine without cooling water flowing thru seawater pickup pump (in next step), as pump (and possibly engine) will be damaged.

3. Start engine and run at fast idle (1000-1500 RPM). Add coolant solution to heat exchanger or reservoir, as required, to maintain coolant level at top of filler neck. Reinstall pressure cap after engine reaches normal operating temperature and coolant level remains constant.
4. On engines that are equipped with coolant recovery reservoir (Figure 1), remove cap from reservoir and fill to "Full" mark with coolant solution.
5. With engine still running, check entire cooling system for leaks. Also observe engine temperature gauge to be sure that engine temperature is normal.

SAFETY WARNING: Allow engine to cool down before opening pressure cap (in next step). Sudden loss of pressure (while engine is warm) could cause coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.



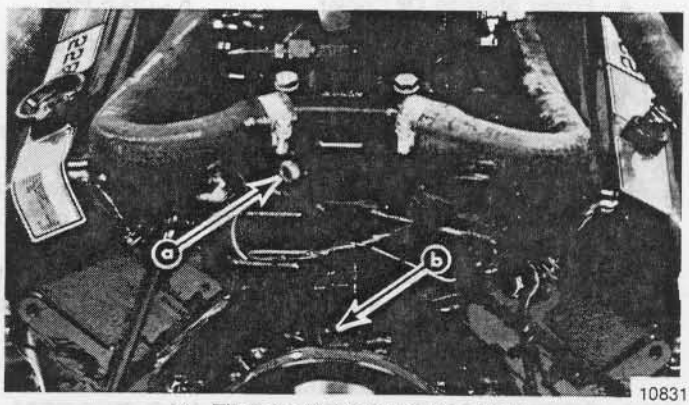
a - Fill to This Mark with Coolant Solution

Figure 1. Coolant Recovery Reservoir

6. Recheck coolant level in heat exchanger or reservoir after first open-throttle boat test and add coolant, if necessary.
7. On engines so equipped, maintain coolant level in coolant recovery reservoir between "Add" and "Full" marks with engine at normal operating temperature.

Inboard 198, 228, 255 and 330 with Rear-Mounted Closed Cooling

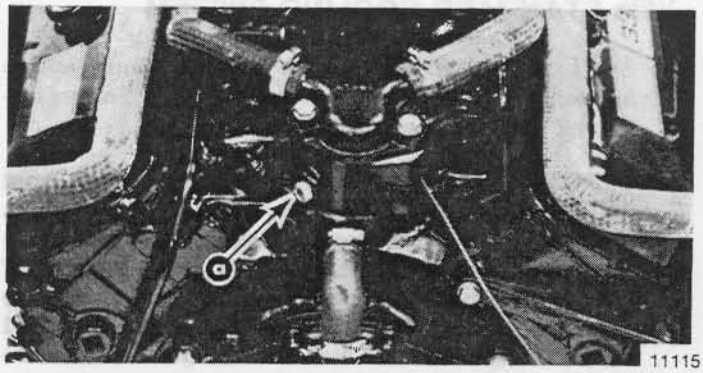
1. Remove pressure cap (fill cap) from heat exchanger.
2. Remove pipe plug from thermostat housing. (Figure 2 or 3) On MerCruiser 198, 228 and 255, also remove pipe plug from circulating pump.
3. Fill fresh water section with coolant solution (thru heat exchanger filler neck), as follows:
   a. MerCruiser 198, 228 and 255
      1) Fill fresh water section with coolant solution until coolant appears at hole in circulating pump from which pipe plug was removed. Coat threads of pipe plug with Perfect Seal (C-92-34227) and reinstall.
      2) Continue filling fresh water section with coolant until coolant appears at hole in thermostat housing from which pipe plug was removed. Coat threads of pipe plug with Perfect Seal and reinstall.
      3) Proceed to fill fresh water section until coolant reaches top of filler neck.



a - Thermostat Housing Pipe Plug
b - Circulating Pump Pipe Plug

Figure 2. Pipe Plug Locations - MerCruiser 198, 228 and 255

   b. MerCruiser 330
      1) Fill fresh water section with coolant solution until coolant appears at hole in thermostat housing from which pipe plug was removed. Coat threads of pipe plug with Perfect Seal (C-92-34227) and reinstall.
      2) Continue to fill fresh water section with coolant until coolant reaches top of filler neck.



a - Thermostat Housing Pipe Plug

Figure 3. Pipe Plug Location - MerCruiser 330

CAUTION: DO NOT operate engine without cooling water flowing thru seawater pickup pump (in next step), as pump (and possibly engine) will be damaged.

4. Start engine and run at fast idle (1000-1500 RPM). Add coolant solution to heat exchanger, as required, to maintain coolant level at top of filler neck. Reinstall pressure cap after engine reaches normal operating temperature and coolant level remains constant.
5. Remove cap from coolant recovery reservoir (Figure 1) and fill to "Full" mark with coolant solution.
6. With engine still running, check entire cooling system for leaks. Also observe engine temperature gauge to be sure that engine temperature is normal.

SAFETY WARNING: Allow engine to cool down before opening pressure cap (in next step). Sudden loss of pressure, while engine is warm, could cause coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

7. Recheck coolant level in heat exchanger after first open throttle boat test and add coolant, if necessary.
8. Maintain level in coolant recovery reservoir between "Add" and "Full" marks with engine at normal operating temperature.

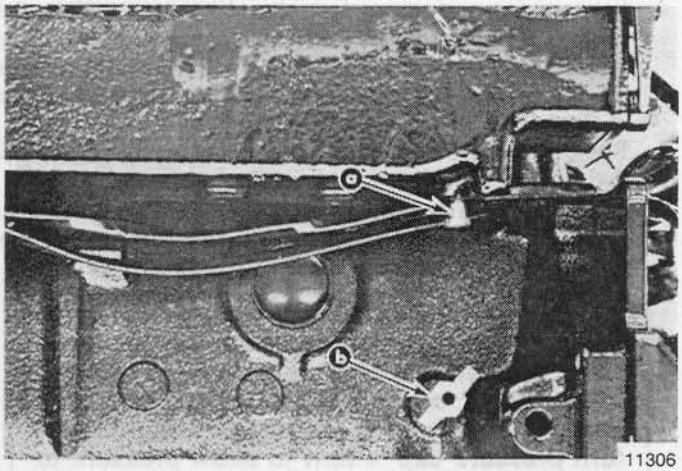
DRAINING INSTRUCTIONS
Stern Drive Models 120/140/165

With STANDARD COOLING SYSTEM

NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

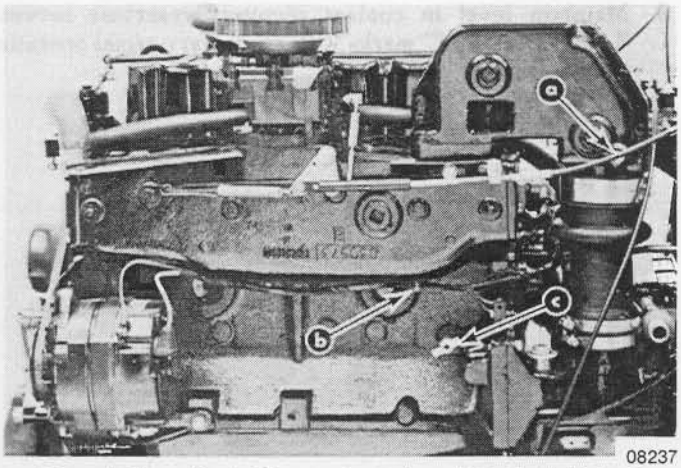
IMPORTANT: When draining cooling system, boat MUST BE positioned so that front of engine is higher than rear, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

1. If possible, place a container under drains to prevent water from draining into boat.
2. Open cylinder block petcock and remove drain plug from exhaust manifold. On Models 140 and 165, also remove drain plug from exhaust elbow. (Figure 1 or 2)



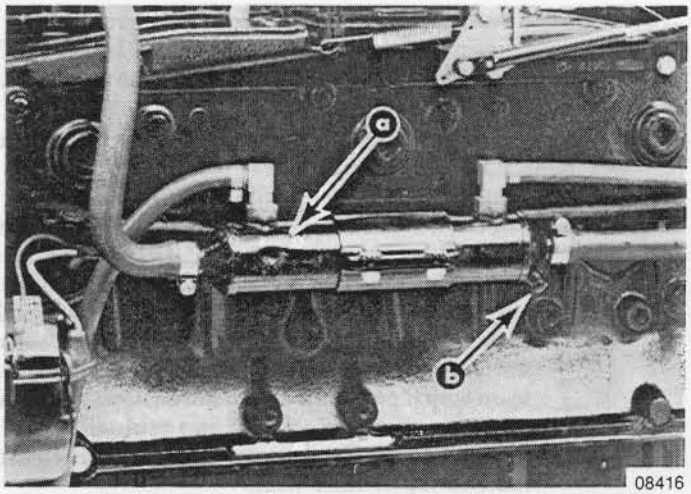
a - Exhaust Manifold Drain Plug b - Cylinder Block Petcock

Figure 1. Model 120 Engine Drain Locations - Port (Left) Side



a - Exhaust Elbow Drain Plug b - Exhaust Manifold Drain Plug
c - Cylinder Block Petcock

Figure 2. Model 140 and 165 Engine Drain Locations - Port (Left) Side



a - Power Steering Oil Cooler b - Drain Plug

Figure 3. Power Steering Oil Cooler Drain Location (on Engines so Equipped)

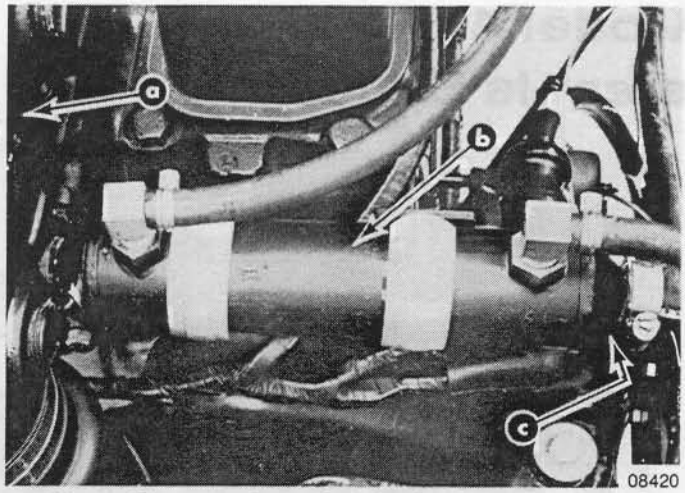
3. If engine is equipped with an exhaust elbow riser, remove drain plug from front end of riser (not shown).
4. If engine is equipped with Power Steering, remove drain plug from bottom-aft end of Power Steering oil cooler. (Figure 3)
5. After cooling system has drained COMPLETELY, coat threads of drain plug with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcock.

With OPTIONAL CLOSED COOLING SYSTEM

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE COMPLETELY drained. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

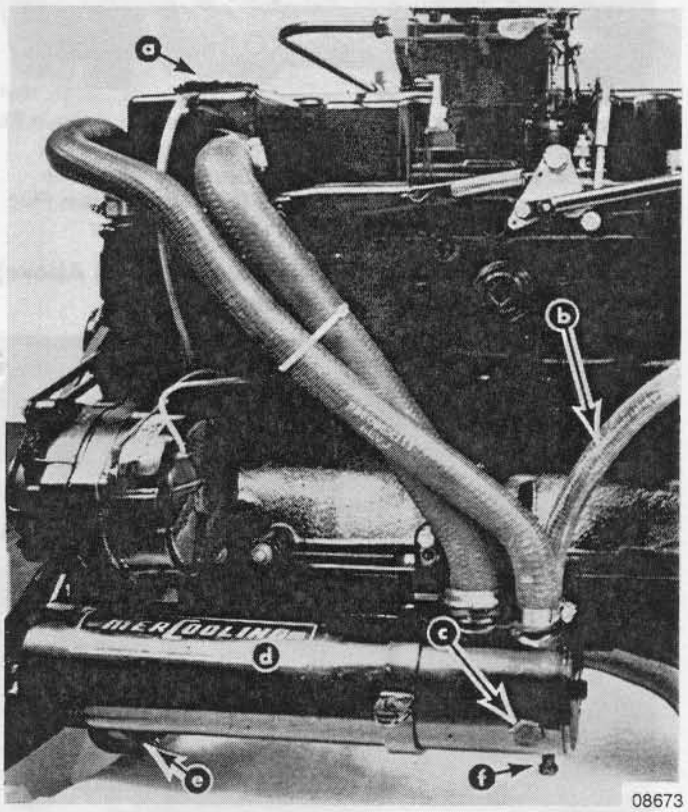
IMPORTANT: When draining cooling system, boat MUST BE positioned so that front of engine is higher than rear, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcock) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

NOTE: Some of the illustrations referred to in the following instructions are of an engine with standard cooling system. Though configuration of engines with Closed Cooling will differ slightly from those in the illustrations, drain locations (where referred to) are the same.



a - Exhaust Elbow b - Power Steering Oil Cooler c - Drain Plug

Figure 4. Power Steering Oil Cooler Drain Location



a - Pressure Cap (Fill Cap)
b - Seawater Inlet Hose
c - Zinc Electrode (if so Equipped)
d - Heat Exchanger
e - Heat Exchanger to Circulating Pump Hose
f - Drain Plug

Figure 5. Heat Exchanger Drain Locations

Draining Seawater Section

1. If possible, place a container under drains to prevent seawater from draining into boat.
2. Remove drain plug from exhaust manifold. Also remove drain plug from exhaust elbow on Models 140 and 165. (Figure 1 or 2)
3. If engine is equipped with an exhaust elbow riser, remove drain plug from front end of riser (not shown).
4. If engine is equipped with Power Steering, remove drain plug from bottom of Power Steering oil cooler. (Figure 4)
5. Disconnect seawater inlet hose and remove drain plug from aft end of heat exchanger. (Figure 5)
6. If heat exchanger is equipped with a zinc electrode (Figure 5), remove electrode and examine for erosion. If eroded less than 25% (when compared to a new electrode), coat threads of electrode with Perfect Seal (C-92-34227) and reinstall. If eroded more than 25%, install a new electrode.
7. After seawater section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal and reinstall. Reinstall seawater inlet hose to heat exchanger.

Draining Fresh Water Section

1. If possible, place a container under drains to prevent coolant from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

2. Remove pressure cap (fill cap) from reservoir. (Figure 5)
3. Open cylinder block petcock on port (left) side of block. (Figure 1 or 2)
4. Disconnect heat exchanger to circulating pump hose from front end of heat exchanger and lower the hose to allow coolant to drain. (Figure 5)
5. If so equipped, remove coolant recovery reservoir from mounting bracket and discharge coolant.
6. After fresh water section of cooling system has drained COMPLETELY, close cylinder block petcock and reconnect hose to heat exchanger.

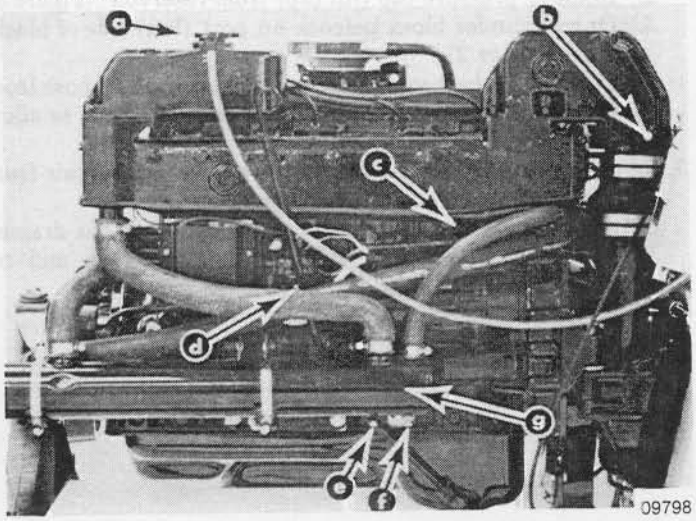
Stern Drive Model 470
(Closed Cooling System Is Standard)

CAUTION: For winter storage, fresh water section of Closed Cooling System should be kept filled with a 50/50 solution of ethylene glycol (anti-freeze) and pure soft water, but seawater section MUST BE drained COMPLETELY. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

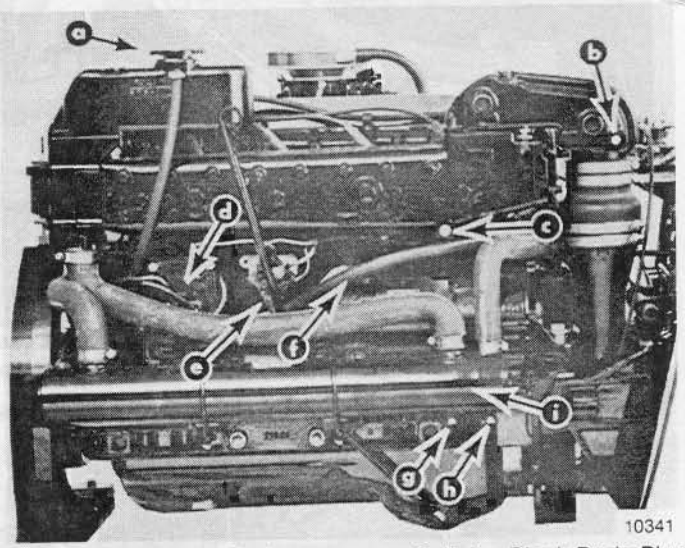
DRAINING SEAWATER SECTION

1. If possible, place a container under drains to prevent seawater from draining into boat.
2. Remove drain plug from exhaust elbow and seawater drain plug from heat exchanger. (Figure 6 or 7, as applicable)
3. If engine is equipped with an exhaust elbow riser, remove drain plug from front end of riser (not shown).
4. On engines with water-cooled voltage regulator (Serial No. 4886620 and above), disconnect seawater inlet hose from regulator. (Figure 7)
5. If engine is equipped with Power Steering, remove drain plug from bottom-aft end of Power Steering oil cooler. (Figure 8)
6. After seawater section has drained completely, coat threads of drain plug with Perfect Seal (C-92-34227) and reinstall. Reconnect seawater inlet hose to regulator.



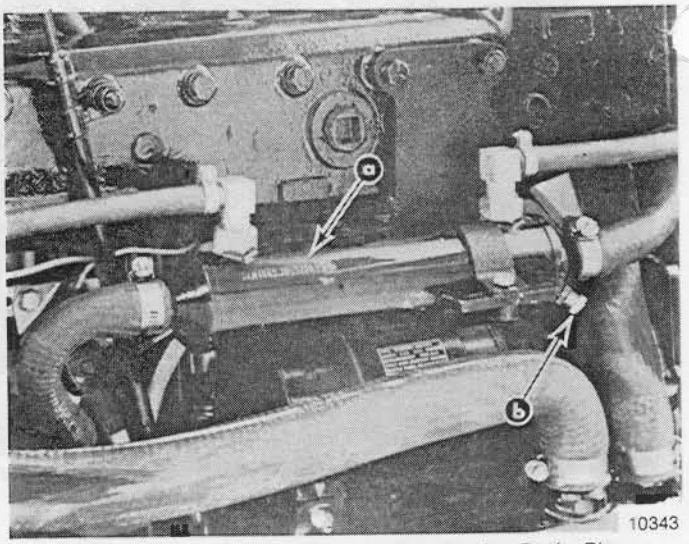
a - Pressure Cap (Fill Cap)
b - Exhaust Elbow Drain Plug
c - Exhaust Manifold Drain Plug
d - Cylinder Block Drain Plug
e - Fresh Water Drain Plug
f - Seawater Drain Plug
g - Heat Exchanger

Figure 6. Model 470 (Serial No. 4886619 and Below) Engine Drain Locations



a - Pressure Cap (Fill Cap)
b - Exhaust Elbow Drain Plug
c - Exhaust Manifold Drain Plug
d - Water-Cooled Voltage Regulator
e - Cylinder Block Drain Plug (Hidden)
f - Seawater Inlet Hose
g - Fresh Water Drain Plug
h - Seawater Drain Plug
i - Heat Exchanger

Figure 7. Model 470 (Serial No. 4886620 and Above) Engine Drain Locations



a - Power Steering Oil Cooler
b - Drain Plug

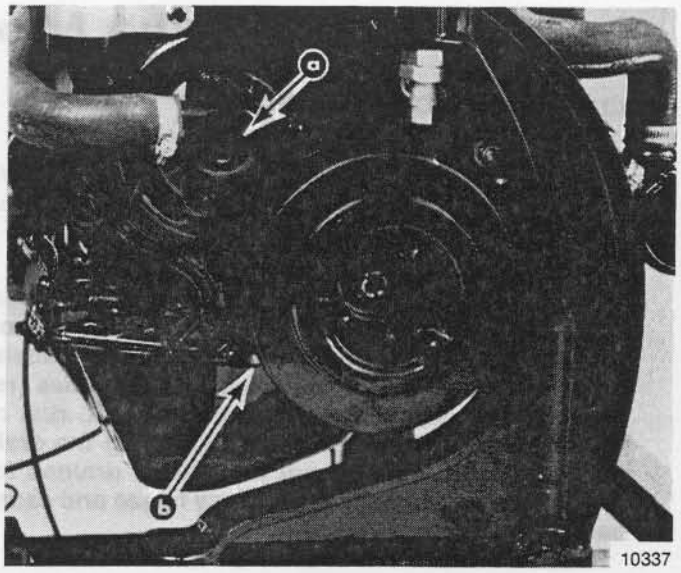
Figure 8. Power Steering Oil Cooler Drain Location (on Engines so Equipped)

DRAINING FRESH WATER SECTION

1. If possible, place a container under drains to prevent coolant from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

2. Remove pressure cap (fill cap) from reservoir. (Figure 6 or 7)
3. Remove fresh water drain plug from heat exchanger, exhaust manifold and cylinder block. (Figure 6 or 7)
4. Remove circulating pump drain plug from bottom of front cover. (Figure 9)
5. Remove coolant recovery reservoir from mounting bracket and discharge coolant. (Figure 6 or 7)
6. After fresh water section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall.



a - Circulating Pump
b - Circulating Pump Drain Plug

Figure 9. Circulating Pump Drain Location

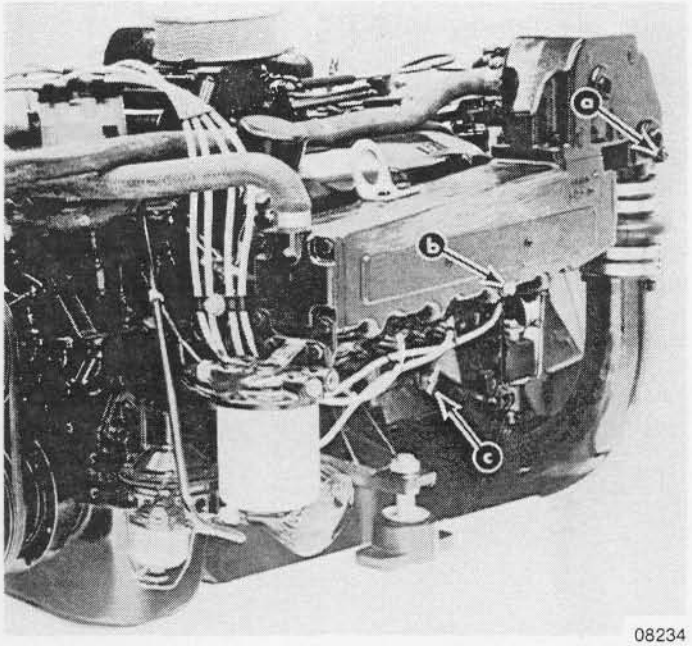
Stern Drive Models 888/255S/233

With STANDARD COOLING

NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

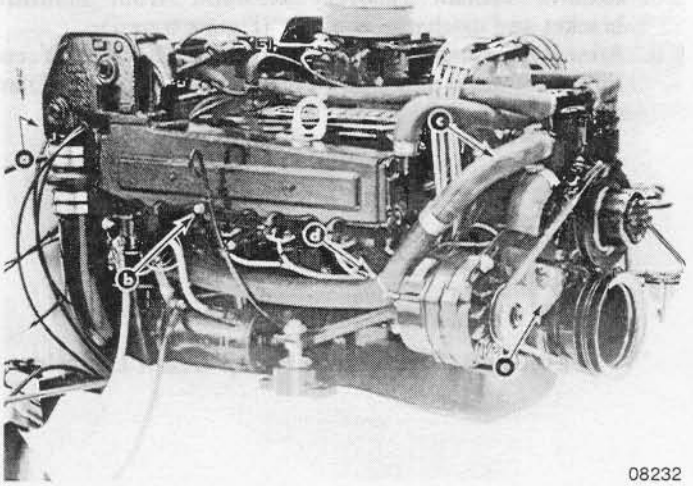
1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from each exhaust manifold and exhaust elbow (port and starboard) and open cylinder block petcock on each side of block. (Figures 1 and 2)
3. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown) remove drain plug from front of each riser.
4. On engines equipped with Power Steering, remove drain plug from bottom-aft end of Power Steering oil cooler. (Figure 3)
5. On engines without Power Steering, disconnect water inlet hose from thermostat housing and lower the hose to allow water to drain from lowest part. (Figure 2)
6. Disconnect thermostat housing to circulating pump hose from circulating pump and lower the hose to allow water to drain. (Figure 2)
7. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hoses.



08234

a - Exhaust Elbow Drain Plug b - Exhaust Manifold Drain Plug
c - Engine Cylinder Block Petcock

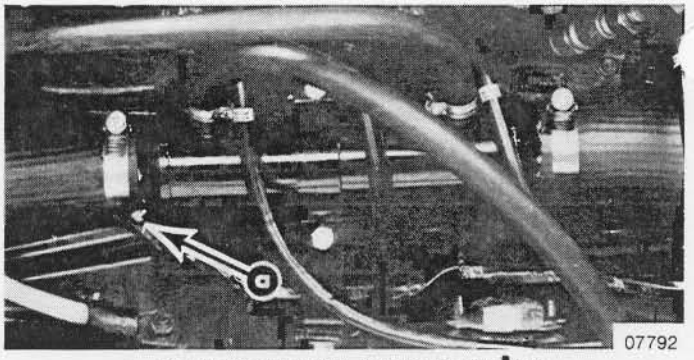
Figure 1. Engine Drain Locations - Port (Left) Side



08232

a - Exhaust Elbow Drain Plug (Hidden)
b - Exhaust Manifold Drain Plug
c - Thermostat Housing Water Inlet Hose
d - Engine Cylinder Block Petcock (Hidden)
e - Thermostat Housing to Circulating Pump Hose

Figure 2. Engine Drain Locations - Starboard (Right) Side



07792

a - Power Steering Oil Cooler Drain Plug

Figure 3. Power Steering Oil Cooler Drain Location (on Engines so Equipped)

With OPTIONAL CLOSED COOLING SYSTEM

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE COMPLETELY drained. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (re-

move petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

NOTE: Some of the illustrations referred to in the following instructions are of an engine with standard cooling system. Though configuration of engines with Closed Cooling will differ slightly from those in the illustrations, drain locations (where referred to) are the same.

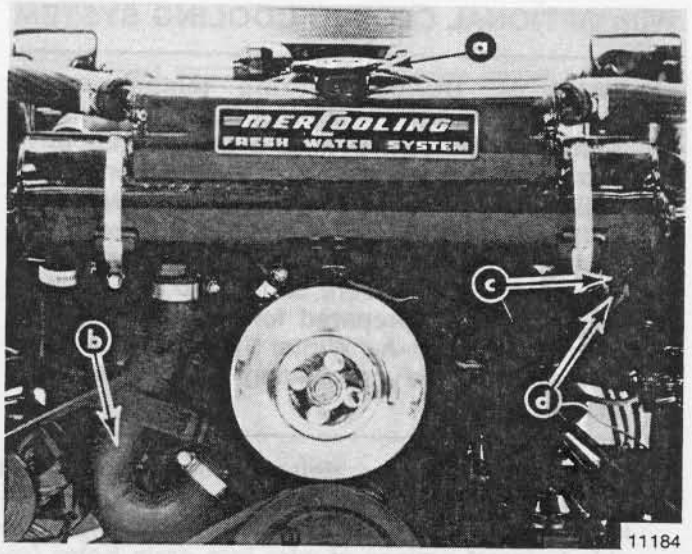
Draining Seawater Section

1. If possible, place a container under drains to prevent seawater from draining into boat.
2. Remove drain plug from port and starboard exhaust elbows. (Figures 1 and 2)
3. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from front end of each riser.
4. Remove drain plug from bottom of heat exchanger. (Figure 4)
5. If heat exchanger is equipped with a zinc electrode (Figure 4), remove electrode and examine for erosion. If eroded less than 25% (when compared to a new electrode), coat threads of electrode with Perfect Seal (C-92-34227) and reinstall. If eroded more than 25%, install a new electrode.
6. On engines with Power Steering, remove drain plug from bottom-aft end of Power Steering oil cooler. (Figure 3)

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

7. Disconnect inlet hose (and outlet hose on engines without Power Steering) from aft end of seawater pickup pump. (Figure 5)

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.



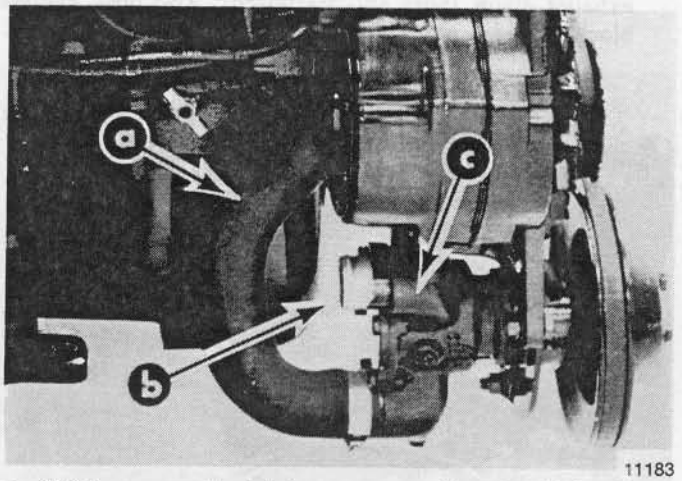
11184

8. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in seawater pickup pump.
9. After seawater section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal and reinstall. Reconnect all hoses and reinstall coil hi-tension lead.

Draining Fresh Water Section

1. If possible, place a container under drains to prevent coolant from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.



11183

a - Outlet b - Inlet c - Seawater Pickup Pump

Figure 5. Seawater Pickup Pump Location

2. Remove pressure cap (fill cap) from heat exchanger reservoir. (Figure 4)
3. Remove drain plug from port and starboard exhaust manifolds and open cylinder block petcocks on each side of block. (Figures 1 and 2)
4. Disconnect heat exchanger to circulating pump hose from circulating pump and bend to allow water to drain. (Figure 4)
5. If so equipped, remove coolant recovery reservoir from mounting bracket and pour out coolant.
6. After fresh water section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose to circulating pump.

a - Pressure Cap (Fill Cap)
b - Heat Exchanger to Circulating Pump Hose
c - Seawater Drain Plug
d - Zinc Electrode (if so Equipped)

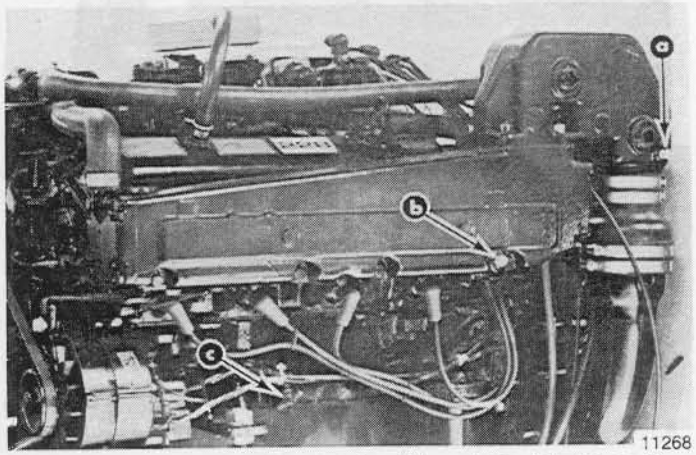
Figure 4. Heat Exchanger Drain Locations

With STANDARD COOLING SYSTEM

NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

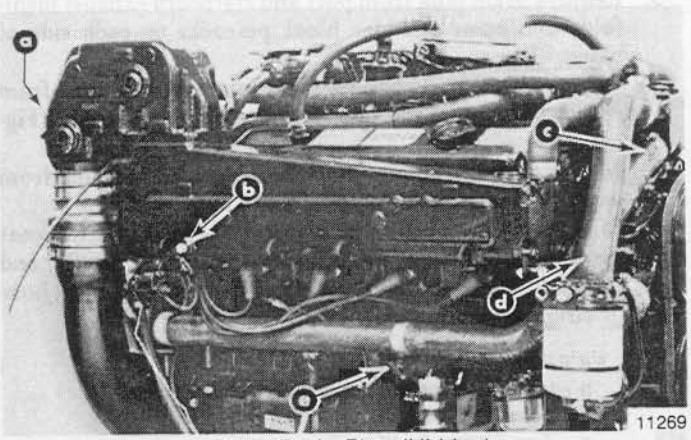
IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from each exhaust manifold and exhaust elbow (port and starboard). Also open cylinder block petcocks on each side of block. (Figures 6 and 7)



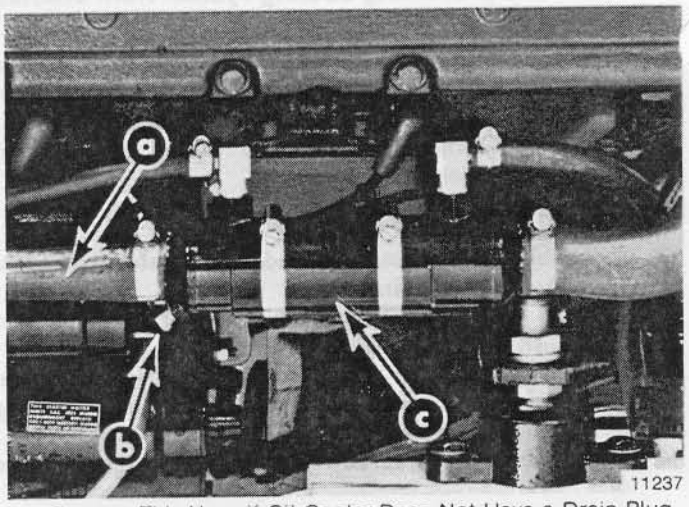
a - Exhaust Elbow Drain Plug b - Exhaust Manifold Drain Plug
c - Cylinder Block Petcock

Figure 6. Engine Drain Locations - Port (Left) Side



a - Exhaust Elbow Drain Plug (Hidden)
b - Exhaust Manifold Drain Plug
c - Thermostat Housing Water Inlet Hose
d - Thermostat Housing to Circulating Pump Hose
e - Cylinder Block Petcock

Figure 7. Engine Drain Locations - Starboard (Right) Side



a - Remove This Hose if Oil Cooler Does Not Have a Drain Plug
b - Drain Plug
c - Power Steering Oil Cooler

Figure 8. Power Steering Oil Cooler Drain Location (on Engines so Equipped)

3. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from front end of each riser.
4. On engines with Power Steering, remove drain plug (if so equipped) from bottom-aft end of Power Steering oil cooler. (Figure 8) If oil cooler does not have a drain plug, disconnect hose from aft end of oil cooler.
5. On engines without Power Steering, disconnect water inlet hose from thermostat housing and lower the hose to allow water to drain from lowest part. (Figure 7)
6. Disconnect thermostat housing to circulating pump hose from circulating pump and bend hose to allow water to drain. (Figure 7)
7. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose(s).

With OPTIONAL CLOSED COOLING SYSTEM

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE COMPLETELY drained. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

Draining Seawater Section

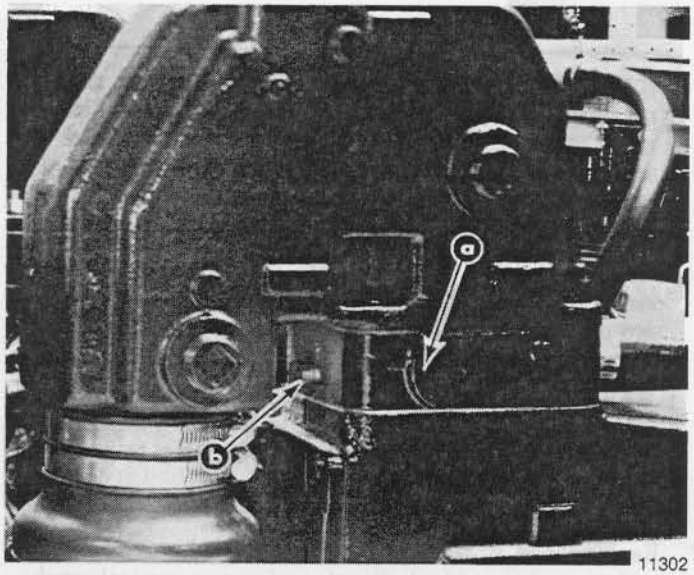
1. If possible, place a container under drains to prevent seawater from draining into boat.
2. Remove drain plugs from port and starboard exhaust elbows. (Figures 6 and 7)
3. On engines with 2-passage type distribution blocks (Figure 9, one block located under each exhaust elbow) remove drain plug from aft end of each block.
4. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from front end of each riser.
5. Remove drain plug from bottom of heat exchanger. (Figure 10)
6. On engines equipped with Power Steering, remove drain plug (if so equipped) from bottom-aft end of Power Steering oil cooler. (Figure 8) Newer style oil coolers do not have drain plugs and are drained by removing seawater pickup pump outlet hose (in next step).

CAUTION: If boat is in water when removing seawater pickup pump inlet hose (in next step), either plug the hose or raise it above water level to prevent water from entering boat.

7. Disconnect inlet and outlet hoses from aft end of seawater pickup pump. (Figure 11) Take note of each hose connection location, as hoses MUST BE reconnected the same way later.

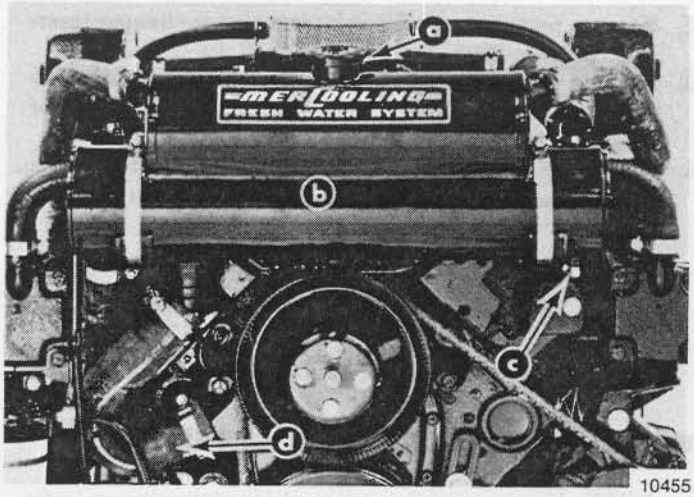
SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

8. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in pump.



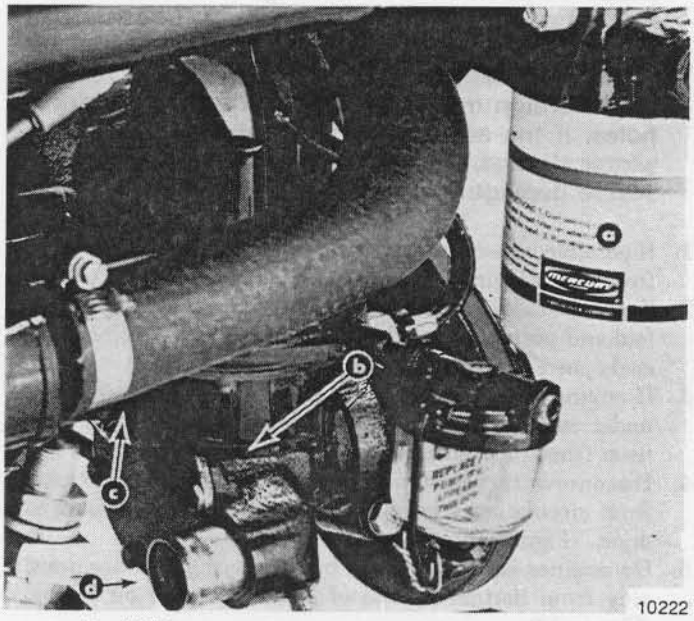
a - Water Distribution Block b - Drain Plug

Figure 9. Two-Passage Type Distribution Block Drain Location (One Block under Each Exhaust Elbow)



a - Pressure Cap (Fill Cap)
b - Heat Exchanger
c - Drain Plug
d - Heat Exchanger to Circulating Pump Hose

Figure 10. Heat Exchanger Drain Locations



a - Fuel Filter
b - Seawater Pickup Pump
c - Outlet (Hidden)
d - Inlet

Figure 11. Seawater Pickup Pump Location

9. After seawater section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Reconnect seawater pickup pump hoses and reinstall coil hi-tension lead.

Draining Fresh Water Section

1. If possible, place a container under drains to prevent coolant from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After cooled down, turn cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

2. Remove pressure cap (fill cap) from heat exchanger reservoir. (Figure 10)
3. Remove drain plugs from port and starboard exhaust manifolds and open cylinder block petcocks on each side of block. (Figures 6 and 7)
4. Disconnect heat exchanger to circulating pump hose from circulating pump and bend hose to allow coolant to drain. (Figure 10)
5. Remove coolant recovery reservoir from mounting bracket and pour out coolant.
6. After fresh water section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose to circulating pump.

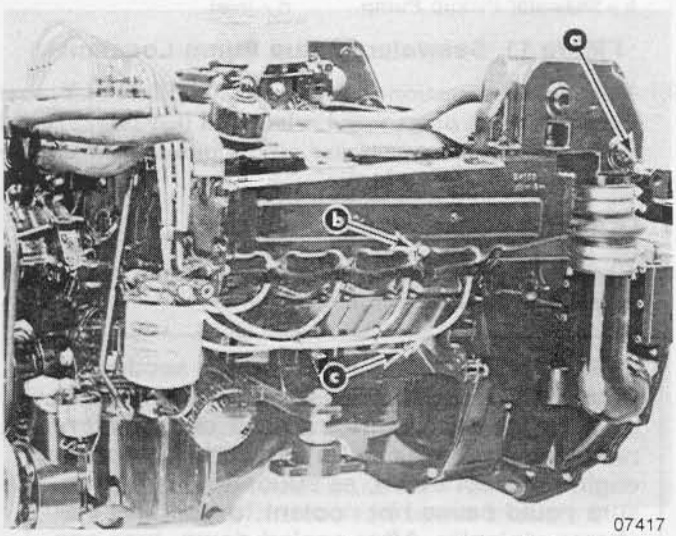
Stern Drive Models 225II-TR/255II-TR (Serial No. 4175499 and Below)/255II-TRS

With STANDARD COOLING SYSTEM

NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

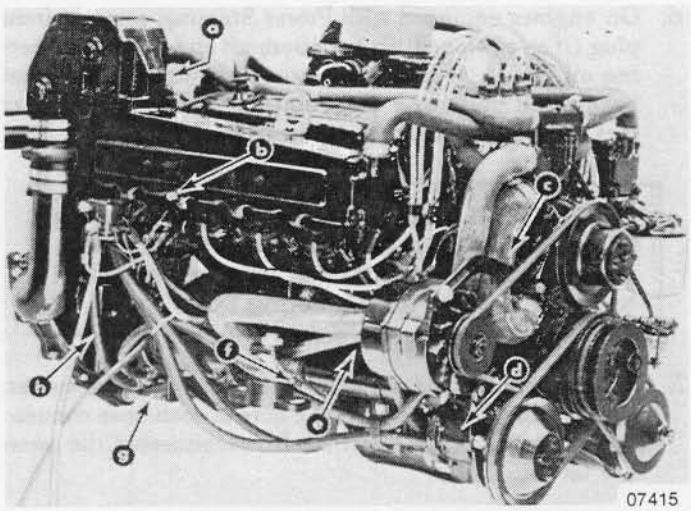
1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from port and starboard exhaust manifold and port exhaust elbow, also open cylinder block petcocks on each side of block. (Figure 12 and 13)
3. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from front of each riser.
4. Disconnect thermostat housing to circulating pump hose from circulating pump and bend hose to allow water to drain. (Figure 13)
5. On engines equipped with Power Steering, remove drain plug from bottom-aft end of Power Steering oil cooler. (Figure 13)



07417

a - Exhaust Elbow Drain Plug b - Exhaust Manifold Drain Plug
c - Cylinder Block Petcock

Figure 12. Engine Drain Locations - Port (Left) Side



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a - Disconnect Transmission Oil Cooler Outlet Hose from Exhaust Elbow
b - Exhaust Manifold Drain Plug
c - Thermostat Housing to Circulating Pump Hose
d - Seawater Pickup Pump
e - Engine Cylinder Block Petcock (Hidden)
f - Power Steering Oil Cooler Drain Plug
g - Transmission Oil Cooler
h - Transmission Oil Cooler Outlet Hose

Figure 13. Engine Drain Locations - Starboard (Right) Side

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

6. Disconnect inlet hose from aft end of seawater pickup pump. (Figure 13) On engines WITHOUT Power Steering, also disconnect outlet hose from pump.

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present during the next step to prevent the possibility of a FIRE.

7. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in seawater pickup pump.
8. Remove transmission oil cooler outlet hose from fitting on side of starboard exhaust elbow and lower hose (below

transmission) to allow water to drain from oil cooler. (Figure 13) If the possibility of freezing exists, fill transmission oil cooler with anti-freeze by pouring it into outlet hose (using a small funnel) until it appears at Power Steering oil cooler drain (on engines with Power Steering) or seawater pickup pump outlet (on engines without Power Steering). Reconnect outlet hose to exhaust elbow.

9. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks, reconnect all hoses and reinstall coil hi-tension lead.

With OPTIONAL CLOSED COOLING SYSTEM

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE COMPLETELY drained. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

NOTE: Some of the illustrations referred to in the following instructions are of an engine with standard cooling system. Though configuration of engines with Closed Cooling will differ slightly from those in illustrations, drain locations (where referred to) are the same.

Draining Seawater Section

1. If possible, place a container under drains to prevent seawater from draining into boat.
2. Remove drain plug from port exhaust elbow. (Figure 12)
3. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from front end of each riser.
4. Remove drain plug from bottom of heat exchanger. (Figure 14)
5. If heat exchanger is equipped with a zinc electrode (Figure 14), remove electrode and examine for erosion. If eroded less than 25%, coat threads of electrode with Perfect Seal (C-92-34227) and reinstall. If eroded more than 25%, install a new electrode.
6. On engines equipped with Power Steering, remove drain plug from bottom-aft end of Power Steering oil cooler. (Figure 13)

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

a - Pressure Cap (Fill Cap)
b - Heat Exchanger to Circulating Pump Hose
c - Seawater Drain Plug
d - Zinc Electrode (if So Equipped)

Figure 14. Heat Exchanger Drain Locations

7. Disconnect inlet hose from aft end of seawater pickup pump. (Figure 13) On engines without Power Steering, also disconnect outlet hose from pump.

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

8. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter to purge any water remaining in seawater pickup pump.
9. Disconnect transmission oil cooler outlet hose from fitting on side of starboard exhaust elbow and lower hose (below transmission) to allow seawater to drain from oil cooler. (Figure 13) If the possibility of freezing exists, fill transmission oil cooler with anti-freeze by pouring it into outlet hose (using a small funnel) until it appears at Power Steering oil cooler drain (on engines with Power Steering) or seawater pickup pump outlet (on engines without Power Steering). Reconnect outlet hose to exhaust elbow.
10. After seawater section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal and reinstall. Reconnect all hoses and reinstall coil hi-tension lead.

Draining Fresh Water Section

1. If possible, place a container under drains to prevent coolant from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

2. Remove pressure cap (fill cap) from heat exchanger reservoir. (Figure 14)
3. Remove drain plug from port and starboard exhaust manifold and open cylinder block petcocks on each side of block. (Figures 12 and 13)
4. Disconnect heat exchanger to circulating pump hose from circulating pump and bend hose to allow coolant to drain. (Figure 14)
5. Remove coolant recovery reservoir from mounting bracket and pour out coolant.
6. After fresh water section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose to circulating pump.

Stern Drive Models 228II-TR, 255II-TR (Serial No. 4175500 and Above), 280II-TRS, 330II-TR and 330II-TRS

With STANDARD COOLING

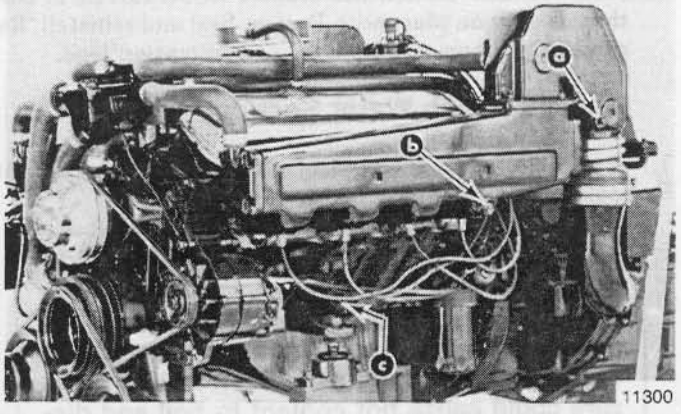
NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

1. If possible, place a container under drains to prevent water from draining into boat.
2. Open cylinder block petcock on each side of block and remove drain plug from port and starboard exhaust manifold. Also remove drain plug (on engines so equipped) from port exhaust elbow. (Figures 15 and 16)
3. On Model 255II-TR and 280II-TRS engines with water distribution blocks (Figure 17, one distribution block located under each exhaust elbow), remove drain plug from side of each block.

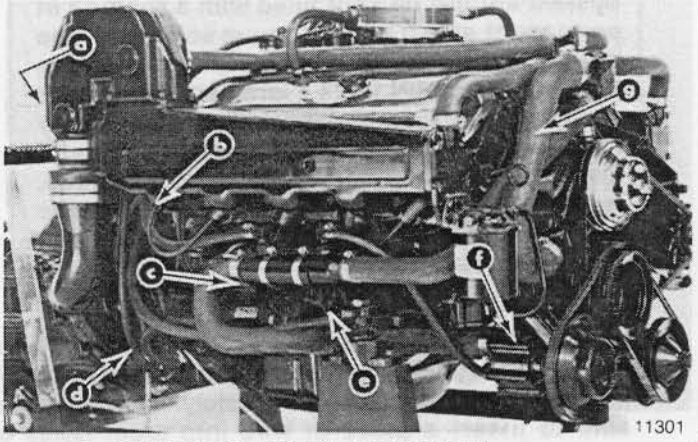
NOTE: Disregard the following step, if engine is equipped with water distribution blocks. (Figure 17)

4. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from end of each riser.



a - Exhaust Elbow Drain Plug b - Exhaust Manifold Drain Plug
c - Cylinder Block Petcock (Hidden)

Figure 15. Typical Engine Drain Locations - Port (Left) Side



a - Exhaust Elbow Drain Plug (Hidden)
b - Exhaust Manifold Drain Plug
c - Power Steering Oil Cooler Drain Plug
d - Transmission Oil Cooler Outlet Hose
e - Cylinder Block Petcock
f - Seawater Pickup Pump
g - Thermostat Housing to Circulating Pump Hose

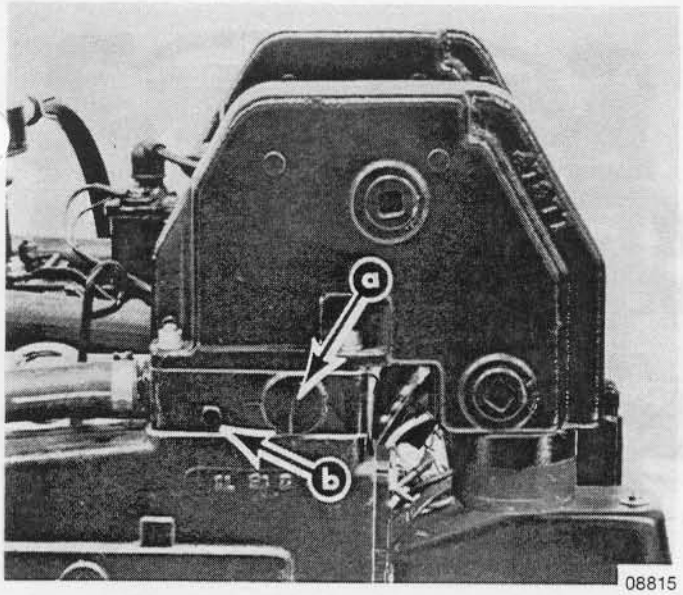
Figure 16. Typical Engine Drain Locations - Starboard (Right) Side

5. Disconnect thermostat housing to circulating pump hose from circulating pump and bend hose to allow water to drain. (Figure 16)
6. On engines with Power Steering, remove drain plug (if so equipped) from bottom-aft end of Power Steering oil cooler. (Figure 16) Newer style oil coolers DO NOT have a drain plug and are drained by removing seawater pickup pump outlet hose (in next step).

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

7. Disconnect inlet and outlet hoses from aft end of seawater pickup pump. (Figure 16) Take note of each hose connection location, as hoses MUST BE reconnected the same way later.

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present during the next step to prevent the possibility of a FIRE.



a - Water Distribution Block b - Drain Plug

Figure 17. Water Distribution Block Drain Location (One Block under Each Exhaust Elbow on Engines so Equipped)

8. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in pump.
9. Remove transmission oil cooler outlet hose from starboard exhaust elbow and lower hose to allow water to drain from oil cooler. (Figure 16) If the possibility of freezing exists, fill transmission oil cooler with anti-freeze by pouring anti-freeze into outlet hose (using a small funnel) until anti-freeze appears at seawater pickup pump outlet connection. Reconnect outlet hose to exhaust elbow.
10. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks, reconnect all hoses and reinstall coil hi-tension lead.

With OPTIONAL CLOSED COOLING SYSTEM

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE COMPLETELY drained. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

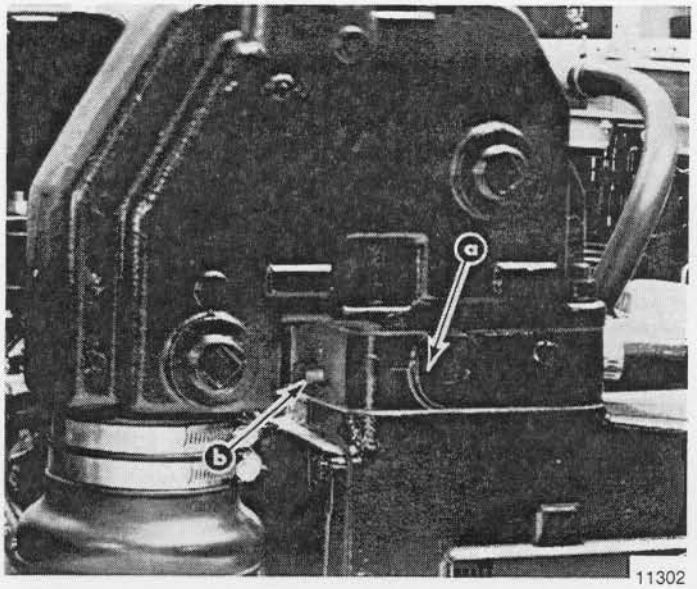
NOTE: Some of the illustrations referred to in the following instructions are of an engine with standard cooling system. Though configuration of engines equipped with Closed Cooling will differ slightly from those in illustrations, drain locations (where referred to) are the same.

Draining Seawater Section

1. If possible, place a container under drains to prevent seawater from draining into boat.
2. Remove drain plug (on engines so equipped) from port exhaust elbow. (Figure 15) Older Model 255II-TR and 280II-TRS engines do not have a drain plug.
3. On all engines (except Model 228 with Serial No. 4888930 and above), remove drain plug from aft end of port and starboard distribution blocks. (Figure 18, one block located under each exhaust elbow).
4. Model 228 engines (with Serial No. 4888930 and above) only: If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from front end of each riser.
5. Remove drain plugs from bottom of heat exchanger. (Figure 19)
6. If heat exchanger is equipped with a zinc electrode (Figure 19), remove electrode and examine for erosion. If eroded less than 25%, coat threads of electrode with Perfect Seal (C-92-34227) and reinstall. If eroded more than 25%, install a new electrode.
7. On engines with Power Steering, remove drain plug (if so equipped) from bottom aft end of Power Steering oil cooler. (Figure 16) Newer style oil coolers do not have a drain plug and will be drained by removing seawater pickup pump outlet hose (in next step).

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

8. Disconnect inlet and outlet hoses from aft end of seawater pickup pump. (Figure 16) Take note of each hose connection location, as hoses MUST BE reconnected the same way later.



a - Water Distribution Block b - Drain Plug

Figure 18. Water Distribution Block Drain Location (One Block under Each Exhaust Elbow)

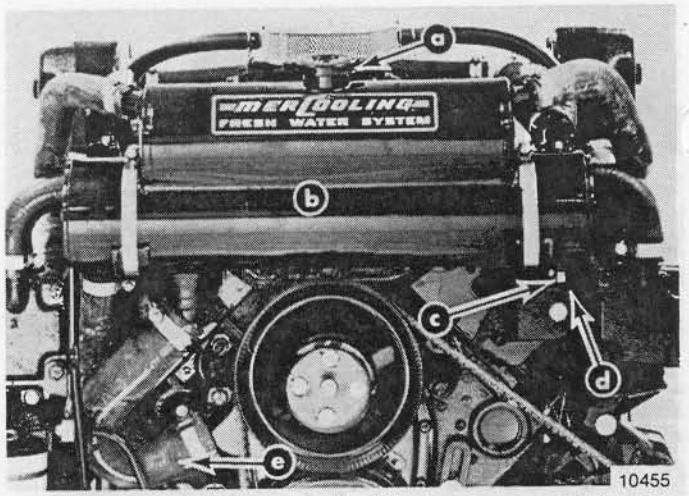
SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

9. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in seawater pickup pump.
10. Remove transmission oil cooler outlet hose from starboard exhaust elbow and lower hose to allow water to drain from oil cooler. (Figure 16) If the possibility of freezing exists, fill transmission oil cooler with anti-freeze by pouring anti-freeze into outlet hose (using a small funnel) until anti-freeze appears at seawater pickup pump outlet connection. Reconnect outlet hose to exhaust elbow.

Draining Fresh Water Section

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

1. Remove pressure cap (fill cap) from heat exchanger reservoir. (Figure 19)



a - Pressure Cap (Fill Cap) b - Heat Exchanger c - Drain Plug
d - Zinc Electrode (if So Equipped, Hidden)
e - Heat Exchanger to Circulating Pump Hose

Figure 19. Heat Exchanger Drain Locations

2. Remove drain plug from port and starboard exhaust manifold and open cylinder block petcocks on each side of block. (Figures 15 and 16)
3. Disconnect heat exchanger to circulating pump hose from circulating pump and bend hose to allow coolant to drain. (Figure 19)
4. If so equipped, remove coolant recovery reservoir from mounting bracket and pour out coolant (not shown).
5. After fresh water section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose to circulating pump.

Inboard and V-Drive Models 225/233/255 (Serial No. 4178299 and Below)

With STANDARD COOLING SYSTEM

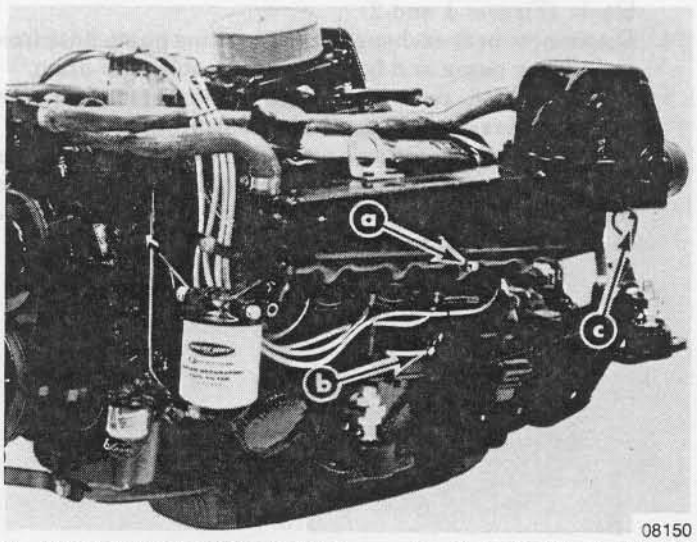
NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage Marine Engines", before proceeding with draining instructions.

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

NOTE: The following illustrations are of inboard engines. On V-drive engines, exhaust elbow drain locations will be slightly different (exhaust elbows are reversed). All other drain locations will be the same.

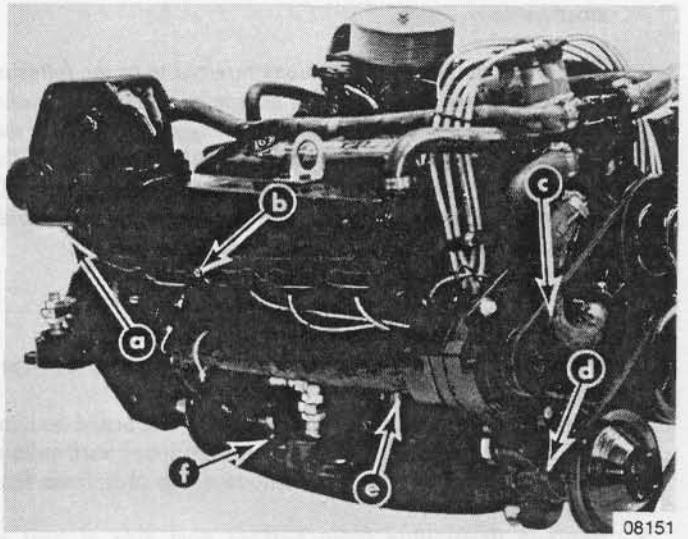
1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plugs from each exhaust manifold and exhaust elbow (port and starboard) and open cylinder block petcocks on each side of block. (Figures 1 and 2)
3. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from front end of each riser.
4. Remove drain plug from bottom-aft end of transmission oil cooler. (Figure 2)
5. Disconnect thermostat housing to circulating pump hose from circulating pump and bend hose to allow water to drain. (Figure 2)

CAUTION: If boat is in water when removing seawater pickup pump inlet hose (in next step), either plug the hose or raise it above water level to prevent water from entering boat.



a - Exhaust Manifold Drain Plug b - Cylinder Block Petcock
c - Exhaust Elbow Drain Plug

Figure 1. Engine Drain Locations - Port (Left) Side



a - Exhaust Elbow Drain Plug
b - Exhaust Manifold Drain Plug
c - Thermostat Housing to Circulating Pump Hose
d - Seawater Pickup Pump
e - Cylinder Block Petcock (Hidden)
f - Transmission Oil Cooler Drain Plug

Figure 2. Engine Drain Locations - Starboard (Right) Side

6. Disconnect inlet hose from aft end of seawater pickup pump. (Figure 2)

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

7. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in pump.
8. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks, reconnect all hoses and reinstall coil hi-tension lead.

With OPTIONAL CLOSED COOLING SYSTEM

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE drained COMPLETELY. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions (see "Index").

IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cool-

ing system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

NOTE: Some of the illustrations referred to in the following instructions are of an inboard engine with standard cooling system. Though configuration of engines equipped with Closed Cooling System will differ slightly from those in illustrations, drain locations (where referred to) are the same. On V-drive engines, exhaust elbow drain location will be slightly different (elbows are reversed).

Draining Seawater Section

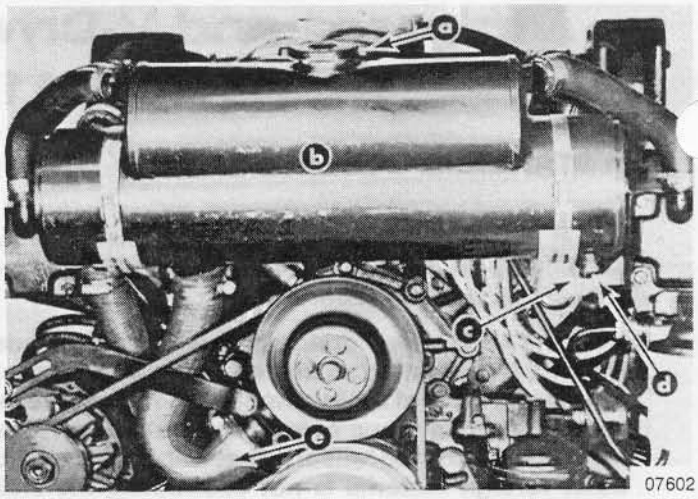
1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plugs from port and starboard exhaust elbow. (Figures 1 and 2) If engine is equipped with exhaust elbow risers (not shown), remove drain plug from front end of each riser.
3. Remove drain plug from bottom port side of heat exchanger. (Figure 3)
4. If heat exchanger is equipped with a zinc electrode (Figure 3), remove electrode and examine for erosion. If eroded less than 25% (when compared to a new electrode), coat threads of electrode with Perfect Seal (C-92-34227) and reinstall. If eroded more than 25%, install a new electrode.
5. Remove drain plug from bottom-aft end of transmission oil cooler. (Figure 2)

CAUTION: If boat is in water when removing seawater inlet hose (in next step), either plug the hose or raise it above water level to prevent water from entering boat.

6. Disconnect inlet hose from aft end of seawater pickup pump. (Figure 2)

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

7. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in pump.
8. After seawater section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal and reinstall. Reconnect hose and reinstall coil hi-tension lead.



a - Pressure cap (Fill Cap)
b - Heat Exchanger
c - Zinc Electrode (if So Equipped)
d - Drain Plug
e - Heat Exchanger to Circulating Pump Hose

Figure 3. Heat Exchanger Drain Locations

Draining Fresh Water Section

1. If possible, place a container under drains to prevent coolant from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

2. Remove pressure cap (fill cap) from heat exchanger reservoir. (Figure 3)
3. Remove drain plug from port and starboard exhaust manifolds and open cylinder block petcocks on each side of block. (Figures 1 and 2)
4. Disconnect heat exchanger to circulating pump hose from circulating pump and bend to allow coolant to drain.
5. If so equipped, remove coolant recovery reservoir from mounting bracket and pour out coolant.
6. After fresh water section has drained COMPLETELY, coat drain plug threads with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose to circulating pump.

Inboard and V-Drive Models 198/228/255 (Serial No. 4178300 and Above)

With STANDARD COOLING SYSTEM

NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

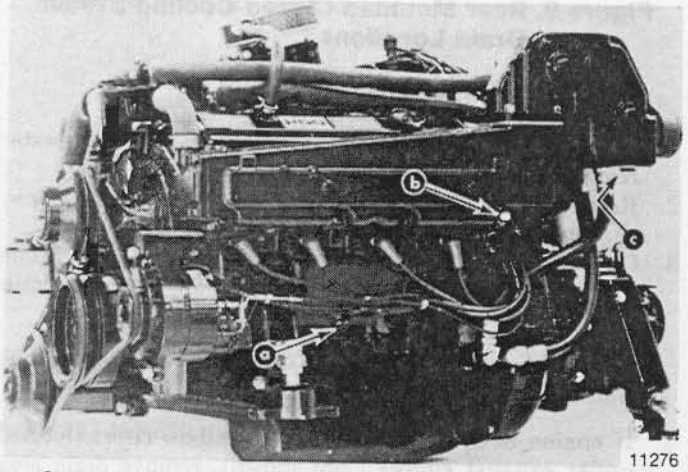
IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

NOTE: The following illustrations are of inboard engines. On V-drive engines, exhaust elbow drain locations will be slightly different (exhaust elbows are reversed). All other drain locations will be the same.

1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from each exhaust elbow and exhaust manifold (port and starboard). Also open cylinder block petcocks on each side of block. (Figures 4 and 5)
3. On Model 255 engines with water distribution blocks (Figure 6, one block under each exhaust elbow), remove drain plug from side of each distribution block.

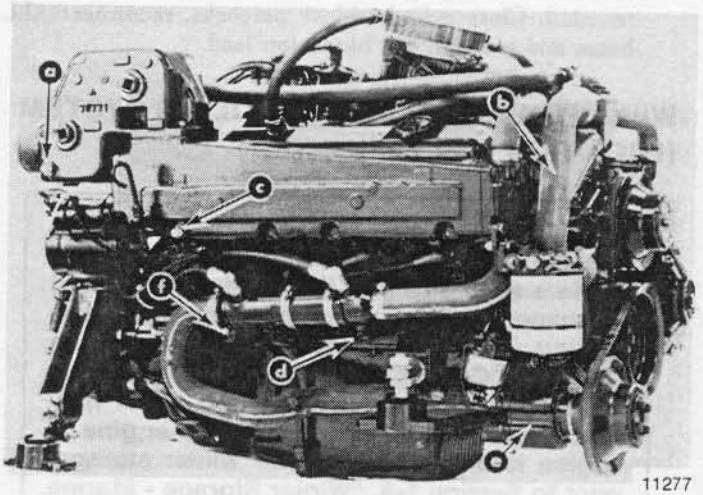
NOTE: Disregard the following step on Model 255 engines with distribution blocks.

4. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from end of each riser.
5. Remove drain plug from bottom-aft end of transmission oil cooler. (Figure 5)
6. Disconnect thermostat housing to circulating pump hose from circulating pump and bend hose to allow water to drain. (Figure 5)



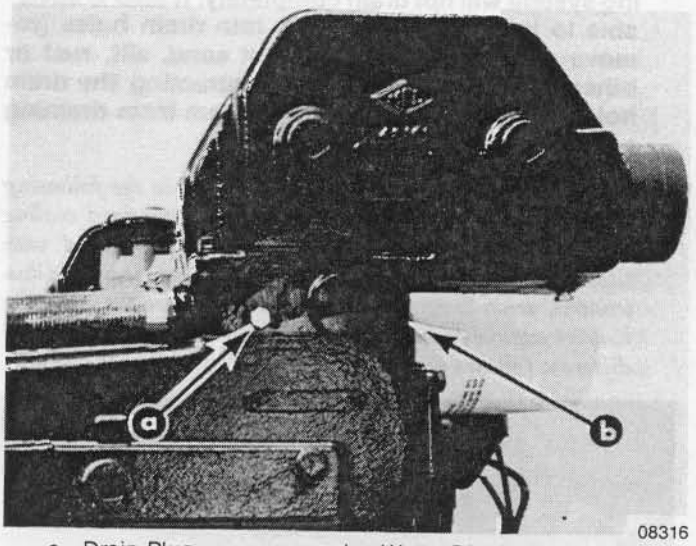
a - Cylinder Block Drain Plug b - Exhaust Manifold Drain Plug
c - Exhaust Elbow Drain Plug

Figure 4. Engine Drain Locations - Port (Left) Side



a - Exhaust Elbow Drain Plug c - Exhaust Manifold Drain Plug
b - Thermostat Housing to Circulating Pump Hose d - Cylinder Block Petcock
e - Seawater Pickup Pump
f - Transmission Oil Cooler Drain Plug

Figure 5. Engine Drain Locations - Starboard (Right) Side



a - Drain Plug b - Water Distribution Block

Figure 6. Water Distribution Block Drain Location (One Block under Each Exhaust Elbow, on Model 255 Engines so Equipped)

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug the hose or raise it above water level to prevent water from entering boat.

7. Disconnect inlet and outlet hoses from aft end of seawater pickup pump. (Figure 5) Take note of each hose connection location, as hoses MUST BE reconnected the same way later.

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

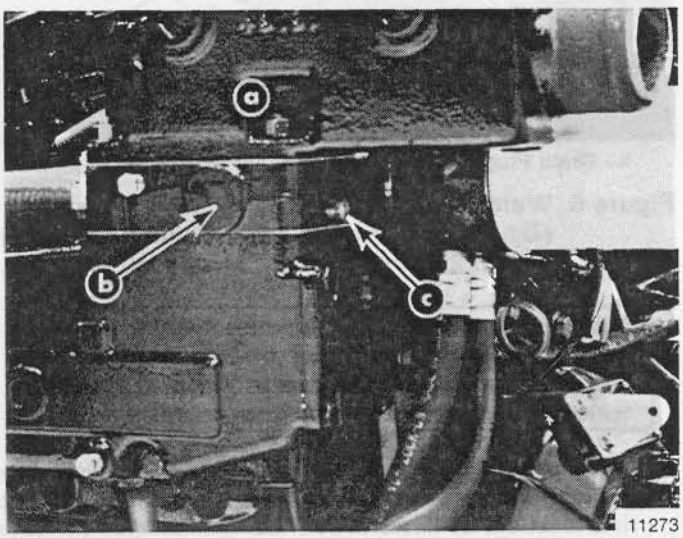
8. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in pump.
9. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks, reconnect ALL hoses and reinstall coil hi-tension lead.

With OPTIONAL CLOSED COOLING SYSTEM (FRONT OR REAR MOUNTED)

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE COMPLETELY drained. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

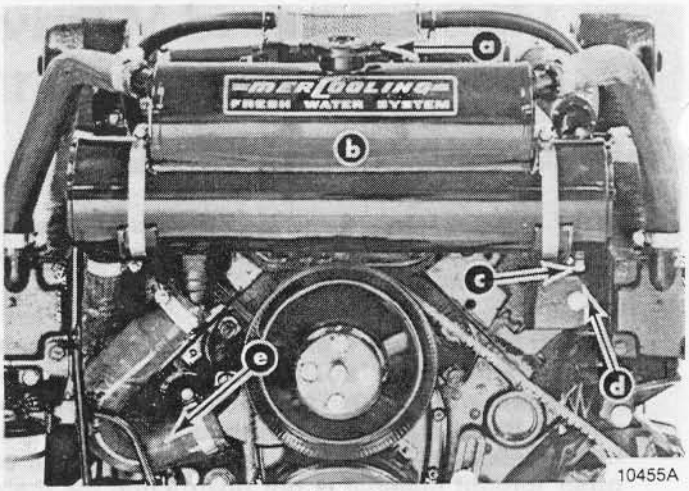
IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

NOTE: Some of the illustrations referred to in the following instructions are of an inboard engine with standard cooling system. Though configuration of engines equipped with Closed Cooling System will differ slightly from those in illustrations, drain locations (where referred to) are the same. On V-drive engines, exhaust elbow drain location will be slightly different (elbows are reversed).



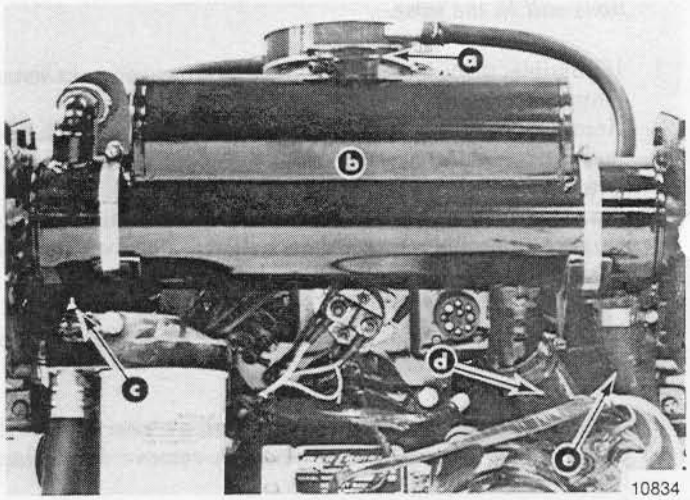
a - Exhaust Elbow
b - Distribution Block
c - Drain Plug

Figure 7. Water Distribution Block Drain Location (One Block under Each Exhaust Elbow, on Engines so Equipped)



a - Pressure Cap (Fill Cap)
b - Heat Exchanger
c - Drain Plug
d - Zinc Electrode (if So Equipped, Hidden)
e - Heat Exchanger to Circulating Pump Hose

Figure 8. Front Mounted Closed Cooling System Drain Locations



a - Pressure Cap (Fill Cap)
b - Heat Exchanger
c - Drain Plug
d - Heat Exchanger to Circulating Pump Hose
e - Transmission Oil Cooler to Heat Exchanger Hose

Figure 9. Rear Mounted Closed Cooling System Drain Locations

Draining Seawater Section

1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from port and starboard exhaust elbow. (Figures 4 and 5)
3. On engines with water distribution blocks (Figure 7, one block located under each exhaust elbow), remove drain plug from aft end of each block.

   NOTE: Disregard the following step on engines equipped with water distribution blocks.

4. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from end of each riser.
5. Remove drain plug from bottom of heat exchanger. (Figure 8 or 9) On engines with rear mounted Closed Cooling

System, also disconnect transmission oil cooler to heat exchanger hose from heat exchanger and lower to allow water to drain.

6. If heat exchanger is equipped with a zinc electrode (Figure 8), remove electrode and examine for erosion. If eroded less than 25% (when compared to a new electrode), coat threads of electrode with Perfect Seal (C-92-34227) and reinstall. If eroded more than 25%, install a new electrode.
7. Remove drain plug from bottom aft end of transmission oil cooler. (Figure 5)

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

8. Disconnect inlet and outlet hoses from aft end of seawater pickup pump. (Figure 5) Take note of each hose connection location, as hoses MUST BE reconnected the same way later.

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

9. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in seawater pickup pump.
10. After seawater section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal and reinstall. Reconnect all hoses and reinstall coil hi-tension lead.

Draining Fresh Water Section

1. If possible, place a container under drains to prevent coolant from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

2. Remove pressure cap (fill cap) from heat exchanger reservoir. (Figure 8 or 9)
3. Remove drain plugs from port and starboard exhaust manifolds and open cylinder block petcocks on each side of block. (Figures 4 and 5)
4. Drain engine circulating pump, as follows:
   a. On engines with front-mounted Closed Cooling: Disconnect heat exchanger to circulating pump hose from circulating pump and bend hose to allow coolant to drain. (Figure 8)
   b. On engines with rear-mounted Closed Cooling: Disconnect heat exchanger to circulating pump hose from heat exchanger and lower hose to allow coolant to drain from pump and hose. (Figure 9)
5. Remove coolant recovery reservoir from mounting bracket and pour out coolant.
6. After fresh water section has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose to circulating pump or heat exchanger.

With STANDARD COOLING SYSTEM

NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

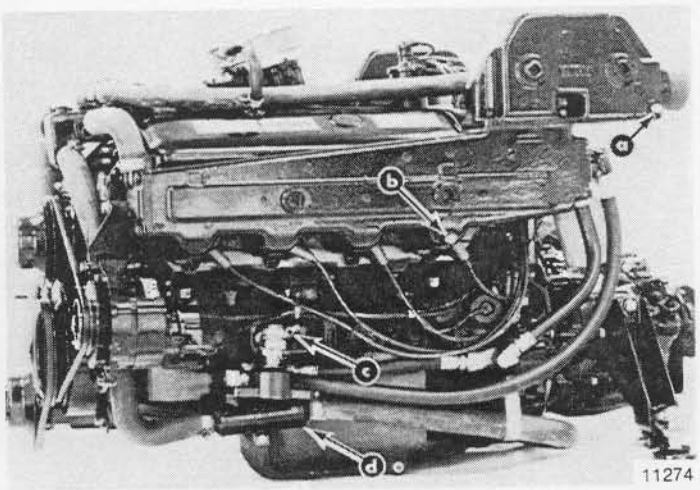
IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

NOTE: The following illustrations are of inboard engines. On V-drive engines, exhaust elbow drain locations will be slightly different (exhaust elbows are reversed). All other drain locations will be the same.

1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from each exhaust manifold and exhaust elbow (port and starboard) and open cylinder block petcocks on each side of block. (Figures 10 and 11)
3. On Model 350 engines with water distribution blocks (Figure 12), remove drain plug from side of each distribution block (one block located under each exhaust elbow).

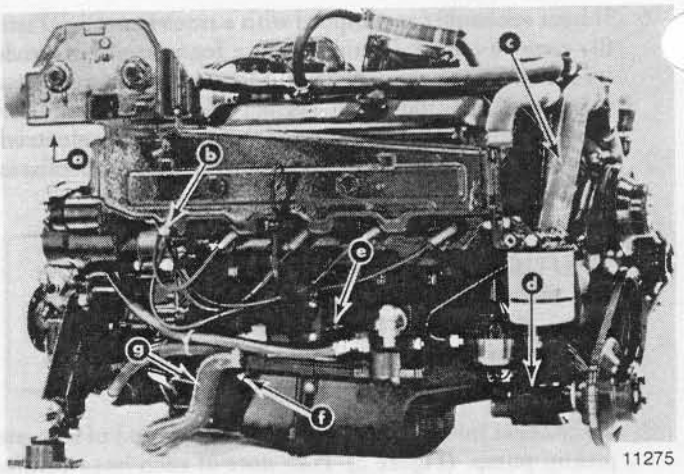
NOTE: Disregard the following step on Model 350 engines with water distribution blocks.

4. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from end of each riser.
5. Remove drain plug from bottom aft end of engine oil cooler. (Figure 10)
6. Remove drain plug from bottom-aft end of transmission oil cooler. Also disconnect transmission oil cooler to engine



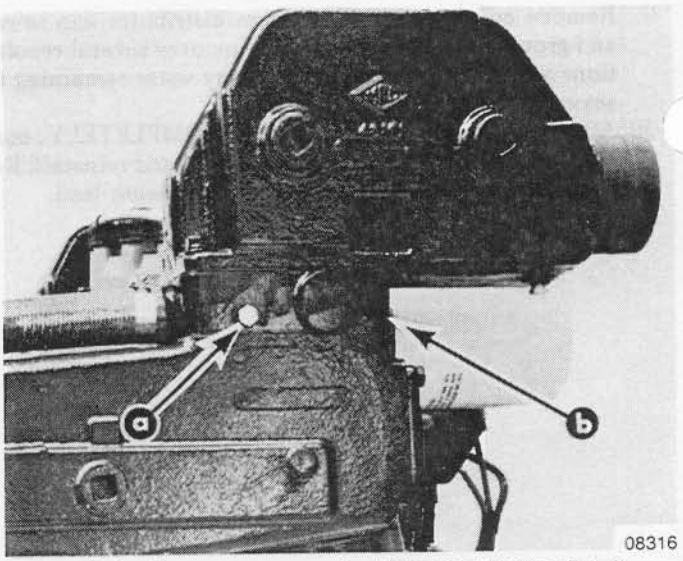
a - Exhaust Elbow Drain Plug
b - Exhaust Manifold Drain Plug
c - Cylinder Block Petcock
d - Engine Oil Cooler Drain Plug (Hidden)

Figure 10. Engine Drain Locations - Port (Left) Side



a - Exhaust Elbow Drain Plug (Hidden)
b - Exhaust Manifold Drain Plug
c - Thermostat Housing to Circulating Pump Hose
d - Seawater Pickup Pump
e - Cylinder Block Petcock
f - Transmission Oil Cooler Drain Plug
g - Transmission Oil Cooler to Engine Oil Cooler Hose

Figure 11. Engine Drain Locations - Starboard (Right) Side



a - Drain Plug b - Water Distribution Block

Figure 12. Water Distribution Block Drain Location (One Block under Each Exhaust Elbow, on Model 350 Engines so Equipped)

oil cooler hose from transmission oil cooler and lower to allow water to drain. (Figure 11)

7. Disconnect thermostat housing to circulating pump hose from circulating pump and bend hose to allow water to drain. (Figure 11)

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

8. Disconnect inlet hose from aft end of seawater pickup pump. (Figure 11)

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

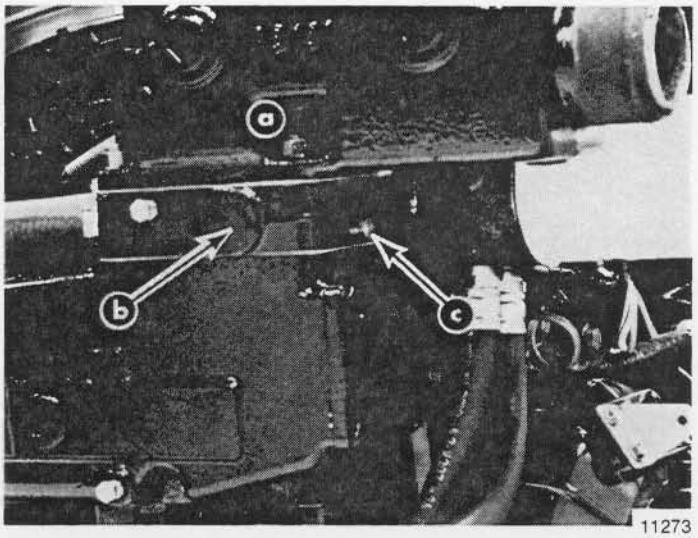
9. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in pump.
10. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks, reconnect all hoses and reinstall coil hi-tension lead.

With OPTIONAL CLOSED COOLING SYSTEM (FRONT or REAR MOUNTED)

CAUTION: During freezing temperature months, fresh water section of Closed Cooling System should be kept filled with a solution of permanent anti-freeze and pure soft water (see "Filling Instructions"), but seawater section MUST BE COMPLETELY drained. If seawater section is not completely drained, water may freeze and cause severe damage to engine. If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

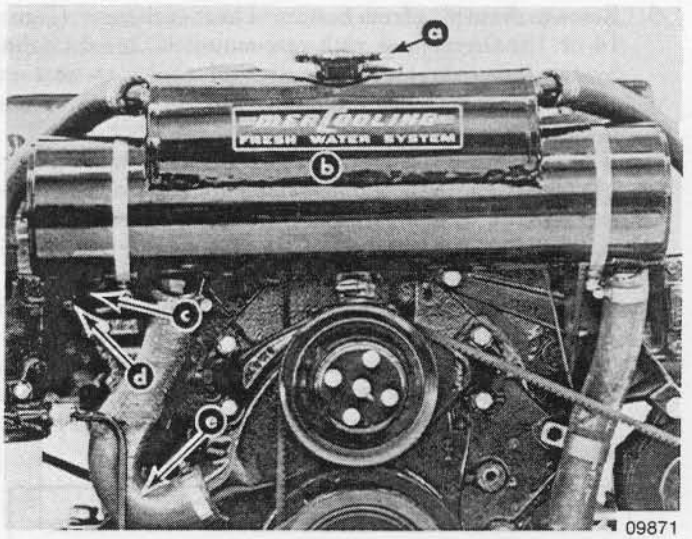
IMPORTANT: When draining cooling system, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes and preventing cooling system from draining completely.

NOTE: Some of the illustrations referred to in the following instructions are of an inboard engine with standard cooling system. Though configuration of engines equipped with Closed Cooling System will differ slightly from those in the illustrations, drain locations (where referred to) are the same.



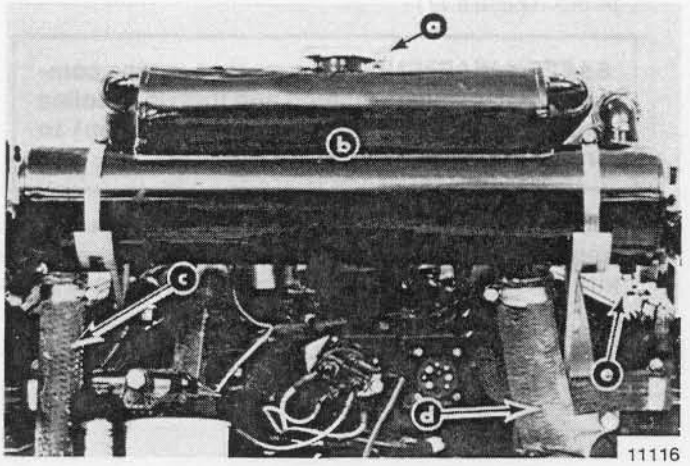
a - Exhaust Elbow b - Distribution Block c - Drain Plug

Figure 13. Water Distribution Block Drain Location (One Block under Each Exhaust Elbow, on Engines so Equipped)



a - Pressure Cap (Fill Cap) c - Drain Plug (Hidden)
b - Heat Exchanger d - Zinc Electrode (if So Equipped)
e - Heat Exchanger to Circulating Pump Hose

Figure 14. Front Mounted Heat Exchanger Drain Locations



a - Pressure Cap (Fill Cap)
b - Heat Exchanger
c - Engine Oil Cooler to Heat Exchanger Hose
d - Heat Exchanger to Circulating Pump Hose (Disconnect at Pump)
e - Drain Plug

Figure 15. Rear Mounted Heat Exchanger Drain Locations

On V-drive engines, exhaust elbow drain location will be slighly different (elbows are reversed).

Draining Seawater Section

1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from port and starboard exhaust elbow. (Figures 10 and 11)
3. On engines with water distribution blocks (Figure 13, one block under each exhaust elbow), remove drain plug from aft end of each distribution block.

   NOTE: Disregard the following step, if engine is equipped with water distribution blocks.

4. If engine is equipped with exhaust elbow risers (located under exhaust elbows - not shown), remove drain plug from end of each riser.

5. Remove drain plug from bottom of heat exchanger. (Figure 14 or 15) On engines with rear-mounted Closed Cooling System, also disconnect engine oil cooler to heat exchanger hose from heat exchanger and lower to allow water to drain.
6. If heat exchanger is equipped with a zinc electrode (Figure 14), remove electrode and examine for errosion. If eroded less than 25%, coat threads of electrode with Perfect Seal (C-92-34227) and reinstall. If eroded more than 25%, install a new electrode.
7. Remove drain plug from bottom-aft end of engine oil cooler. (Figure 10)
8. Remove drain plug from bottom-aft end of transmission oil cooler, also disconnect transmission oil cooler to engine oil cooler hose from transmission oil cooler and lower hose to allow water to drain. (Figure 11)

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

9. Disconnect inlet hose from aft end of seawater pickup pump. (Figure 11)

SAFETY WARNING: Be sure that engine compartment is well-ventilated and that no gasoline vapors are present (during the next step) to prevent the possibility of a FIRE.

10. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to drain any water remaining in pump.
11. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal and reinstall. Reconnect all hoses and reinstall coil hi-tension lead.

Draining Fresh Water Section

1. If possible, place a container under drains to prevent water from draining into boat.

SAFETY WARNING: Fresh water section of Closed Cooling System is equipped with a 14 psi (1kg/cm²) pressure cap (fill cap). Before removing pressure cap (in next step), first allow engine to cool down, as sudden loss of pressure could cause hot coolant to boil and discharge violently. After engine has cooled down, turn pressure cap ¼-turn to allow pressure to escape slowly, then turn cap all-the-way off.

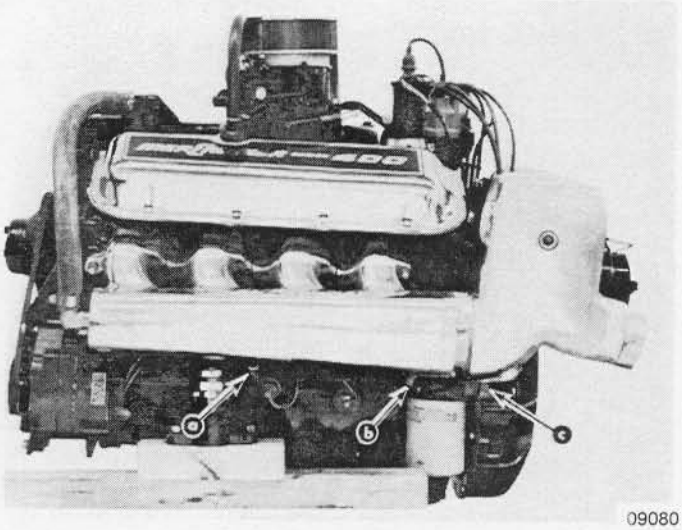
2. Remove pressure cap (fill cap) from heat exchanger. (Figure 14 or 15)
3. Remove drain plug from port and starboard exhaust manifolds and open cylinder block petcocks on each side of block. (Figures 10 and 11)
4. Disconnect heat exchanger to circulating pump hose from circulating pump and bend hose to allow coolant to drain. (Figure 14 or 15)
5. If so equipped, remove coolant recovery reservoir from mounting bracket and pour out coolant.
6. After fresh water section has drained completely, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks and reconnect hose to circulating pump.

Jet Model 400 with Standard Cooling System

NOTE: If engine is being prepared for winter storage, refer to Section 1-A, "Winter Storage - Marine Engines", before proceeding with draining instructions.

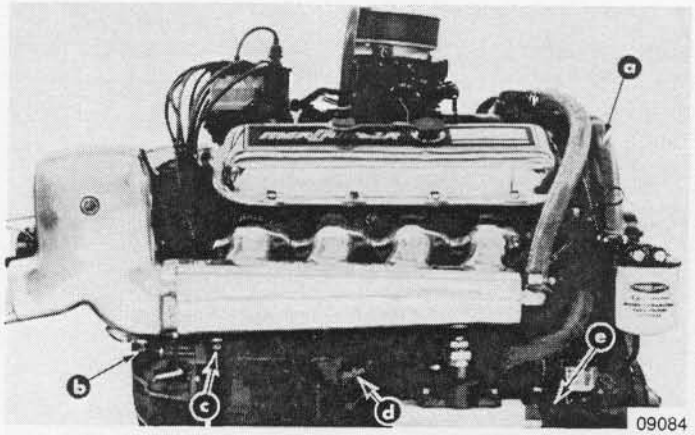
IMPORTANT: When draining Cooling System, boat MUST BE positioned so that engine is level, or cooling system will not drain completely. It also is advisable to insert a piece of wire into drain holes (remove petcocks) to ensure that sand, silt, rust or other foreign material is not obstructing the drain holes. If the engine is not completely drained for winter storage, trapped water may freeze and cause severe damage to engine.

1. If possible, place a container under drains to prevent water from draining into boat.
2. Remove drain plug from each exhaust manifold and exhaust elbow (port and starboard) and open cylinder block petcocks on each side of block. (Figures 1 and 2)
3. Disconnect thermostat housing to circulating pump hose from circulating pump and bend hose to allow water to drain. (Figure 2)



a - Cylinder Block Petcock
b - Exhaust Manifold Drain Plug
c - Exhaust Elbow Drain Plug

Figure 1. Engine Drain Locations - Port (Left) Side



a - Thermostat Housing to Circulating Pump Hose
b - Exhaust Elbow Drain Plug
c - Exhaust Manifold Drain Plug
d - Cylinder Block Petcock
e - Seawater Pickup Pump

Figure 2. Engine Drain Locations - Starboard (Right) Side

CAUTION: If boat is in the water when removing seawater pickup pump inlet hose (in next step), either plug hose or raise it above water level to prevent water from draining into boat.

4. Disconnect inlet and outlet hoses from aft end of seawater pickup pump. (Figure 2) Take note of each hose connection location, as hoses MUST BE reconnected the same way later.

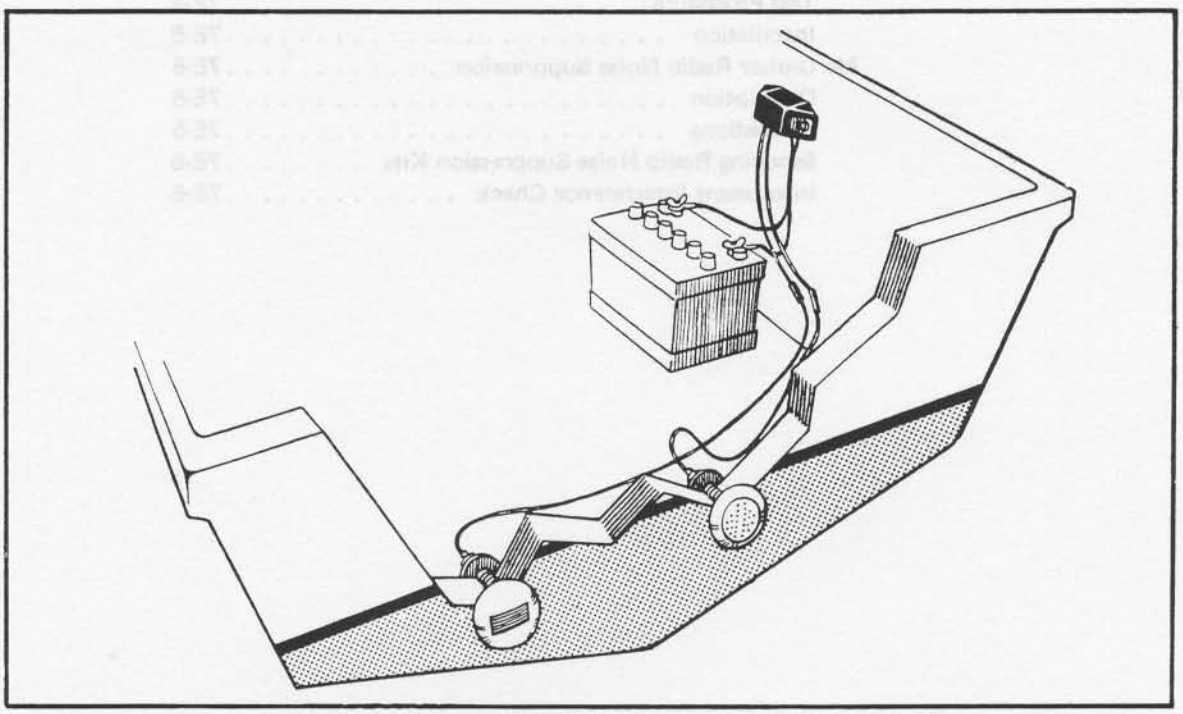
SAFETY WARNING: Be sure that engine compartment is well-ventilated and that there are no gasoline vapors present (during the next step) to prevent the possibility of a FIRE.

5. Remove coil hi-tension lead from distributor cap tower and ground it to block. Crank engine over several revolutions with starter motor to purge any water remaining in pump.
6. After cooling system has drained COMPLETELY, coat threads of drain plugs with Perfect Seal (C-92-34227) and reinstall. Close cylinder block petcocks, reconnect all hoses and reinstall coil hi-tension lead.

SECTION 7 - ACCESSORIES

MERCRUISER

PART E - GENERAL ACCESSORIES



MERCURY MARINE

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MARINE MERCATHODE ANTI-CORROSION SYSTEM
KIT NO. C-66632A2
DESCRIPTION

The system components are designed for trouble-free marine service. Damaged or open connectors generally are the cause of operation difficulties. Use of a MerCathode Monitor is recommended as a customer tool for confirming the operation of the MerCathode System.

1. The automatically-controlled MerCathode Anti-Corrosion System for marine installation protects underwater metals from effects of corrosion on Mercury, MerCruiser and other marine outboards or stern drives.
2. The anode is identified by the male connector fitting. The active element is a platinum coated rectangular metal surface.
3. The reference electrode is identified by a female connector fitting. The sensitive element is internally mounted and is protected by a perforated plastic cover.
4. The solid state controller is potted within a plastic housing which provides 2 mounting holes. The male connector is for the reference electrode and the female connector for the anode. The other 2 leads are for connecting the system to a 12-volt battery. (Figure 1)

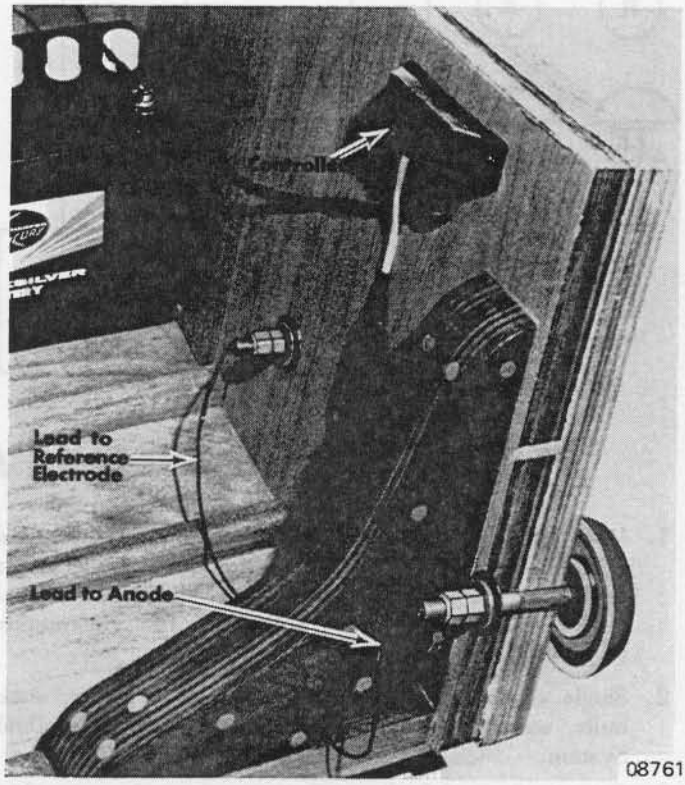


Figure 1. Component Identification

INSTALLATION GUIDE

GENERAL

1. The controller must be installed in a place which is protected from the weather and bilge water.
2. Generally, both electrodes are installed thru the transom below the water line (one on each side of the drive or both between the drives, if there are two transom mounted drives). They also may be installed thru bottom of boat, if necessary.
3. Leads may be spliced, should the installation require changes in lead lengths. They should be soldered and waterproofed.
4. Neither switches nor fuses are required.
5. It is preferred that controller connections be made directly to the battery.
6. A fully charged battery on an inactive boat will protect the drives for a considerable length of time (approximately 60 to 90 days) before the battery will require charging.
7. Do not paint the anode. Surface of reference electrode can be painted with organic tin anti-fouling paints only. Paint must not be permitted to drain through the holes.
8. Connectors must be clean and securely fastened. A lubricant may be used, if necessary, to protect against corrosion, but connectors must fit firmly. It is good practice to check these connections by rotating them on an installed system while observing the reference potential meter.
9. Use drill guide for making two 9/16" (14.3mm) electrode holes through transom, or they will not be perpendicular to surface in order to make a tight seal with "O" rings.
10. For long term dry storage, disconnect MerCathode lead from battery.

MERCATHODE ELECTRODE INSTALLATION thru TRANSOM

1. Locate electrodes on transom at least 3" (76mm) below the water line.

   NOTE: Electrodes are preferably mounted thru transom below water line and one on each side of drive unit.

2. Slip "O" ring (supplied) over electrode lead. Insert lead and electrode stem thru hole in transom and thread first soft neoprene washer, then hard plastic washer, over stud. Install both plastic nuts and tighten them firmly to ensure a good water seal. It may be necessary to use "Silicone Sealer" or other adhesive to temporarily locate "O" ring during assembly.

   NOTE: A manual starting outboard motor can be protected by installing a 12-volt battery for MerCathode System and grounding the engine block to negative (-) terminal of battery.

MERCATHODE CONTROLLER INSTALLATION

1. Secure controller with mounting screws provided.
2. Locate special splash-proof type connectors so they are never exposed to bilge water.

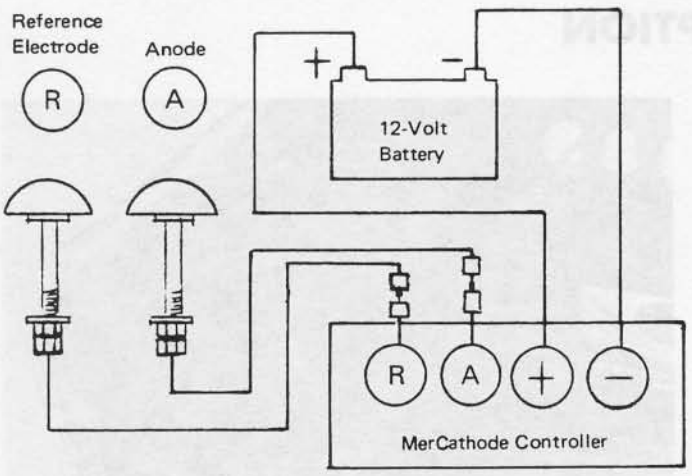


Figure 2. MerCathode Wiring Diagram

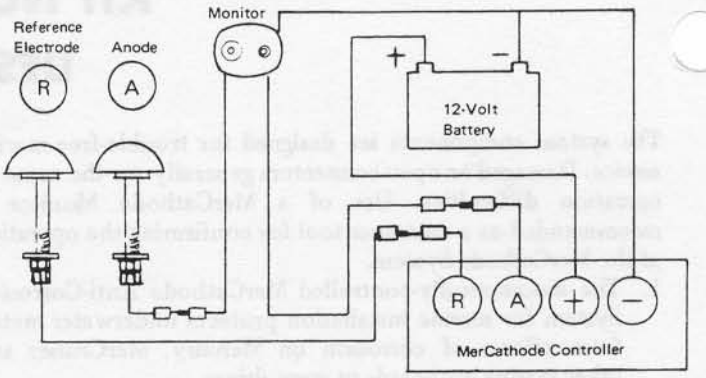


Figure 3. MerCathode with Monitor Wiring Diagram

SPECIAL APPLICATIONS

1. Metal hulled craft may require more than one MerCathode System. To determine need for additional systems, confirm this, as necessary, by using MerCathode Tester (C-91-46802A1) and following test instructions (C-90-46835).
2. Single or dual installations, even on well painted metal hulls, usually are well protected with one MerCathode System.
3. Organic tin anti-fouling paints are the only ones which may be safely applied to aluminum drives.
4. If dual installations are electrically isolated from each other, it will be necessary to inter-connect negative (-) battery terminals or to use a separate MerCathode System on each drive.
5. Bronze propellers on aluminum drives will tend to drop reading, obtained with MerCathode Tester, below 940 millivolts. This test must be conducted only when a "Quicksilver Isolator" is installed or when boat is not connected to shore power. If reference potential is below 890 millivolts, an additional MerCathode is recommended.
6. For houseboats and larger craft equipped for shore-based electric power, a "Quicksilver Isolator" is necessary to prevent establishing a galvanic cell thru the green grounding line in power cable, in order to prevent overloading of MerCathode System.

MAINTENANCE

1. Keep protected metals reasonably well-painted to conserve necessary cathodic protection current.
2. Handle anode carefully so that platinum will not wear from titanium metal base.
3. Never apply paint or coating of any kind over active anode surface.

NOTE: Use Quicksilver Anti-Corrosion Grease (C-92-63290), Anti-Corrosion Oil (C-92-63281) and Perfect Seal (C-92-34227) and use only organic tin anti-fouling paints.

CHECKING

A properly installed MerCathode System will function trouble-free, however, use of MerCathode Monitor is recommended.

As routine procedure, it is suggested that dealer always use the MerCathode Tester (C-91-46802A1) when visiting a customer's MerCathode-equipped boat to confirm that reference potential is satisfactory.

Test electrode installation after launching to be sure no leaks exist.

NOTE: An active anode will not foul. If it does, system is non-operative.

The reference electrode will foul, but this does not spoil accuracy of control.

Proper shore power installations are made with a (green) safety grounding lead which is connected to common boat ground. All boats, which are wired to receive shore power, must be equipped with Quicksilver Isolator or an Isolation Transformer to prevent forming galvanic couple between aluminum drive and metals, such as steel, brass, bronze and copper which are also interconnected with grounding lead. A MerCathode System may not be able to protect aluminum drives on grounded boat without Quicksilver Isolator.

MERCATHODE TESTER (C-91-46802A1)
TEST PROCEDURES

GENERAL DESCRIPTION

The MerCathode Tester is a specially-constructed test instrument used to monitor operation of MerCathode Anti-Corrosion System and to check operation of components in order to locate any malfunction that may exist. Test Meter (C-91-46802A1) is a combination DC voltmeter and millimeter. Test MerCathode System periodically to assure proper protection. The MerCathode System consists of 3 components (listed, following) which are factory-sealed and cannot be repaired, therefore, should be replaced individually. Supplementary tests with the tester are recommended even though the customer's system includes a MerCathode Monitor. The components are:

1. Automatic protector control (controller) which is mounted inside boat.
2. "Anode" electrode which is mounted thru transom.
3. "Reference" electrode which is mounted thru the transom to govern controller so that it continuously provides proper protective current via anode (female connector).

Protection against corrosion has been achieved when reference potential reads between 0.9 and 1.05 on red scale. If drive is equipped with new clean zinc anodes, a satisfactory reference potential may be observed on test meter without installation of MerCathode System. Zinc anodes, however, are sacrificial, and continued protection can be achieved only by installation of MerCathode System. Zinc anodes will provide interim protection, should battery be removed from boat or discharged. A drive with new paint system may have reference potential of 1.05 for short time because of temporary over-protection by zince anode. Some craft may require more than one MerCathode System. Need for additional MerCathode Systems may be determined by test within "Special Applications" (use "Index"). DO NOT paint "anode".

MERCATHODE TESTER FUNCTIONS

1. To monitor overall system operation.
2. To check performance of reference electrode.
3. To check effectiveness of anode.
4. To check performance of automatic protector control (controller).

NOTE: During tests, use a properly-charged 12-volt battery and keep boat in water with electrodes immersed below waterline.

TEST "PERFORMANCE" PROCEDURE

1. Place test meter switch in direction of red arrow. Connect ground lead of meter to engine ground or negative (-) terminal side of battery. Immerse half cell in water (reference electrode).
2. Read between 0.9 and 1.05 on meter red scale, then disconnect reference electrode lead from protector control at quick disconnect and wait one minute. If meter reading increases, system is operating properly and no further tests are necessary. Proceed with following tests if readings were not as described above.

TEST "REFERENCE ELECTRODE" and "ANODE" PROCEDURE

1. Disconnect both electrode leads from MerCathode controller at quick disconnect and connect ground lead of meter to engine ground or negative (-) terminal side of battery.
2. Plug adaptor (3-terminal lead furnished with tester) into female quick disconnect on reference electrode lead, then press adaptor clip into screen on meter half cell.
3. Readings between 0.4 and 1.05 on meter red scale indicate suitable reference electrode response. If meter reading is not within this range, replace "reference electrode". Check "anode" in Step 4, following.
4. Remove reference electrode lead from adaptor and connect "anode" lead at quick disconnect into adaptor, then press clip into screen on half cell.
5. Readings between 0.8 and 2.0 on meter red scale indicate proper "anode" operation, that it is not shorted and that platinum surface is intact. If meter reading is not within this range, replace the "anode".

TEST of CONTROLLER

1. In event anode and reference electrode have tested properly - and,
2. All quick disconnect connections have good electrical continuity - and,
3. Battery is charged, and battery terminals are properly connected,
4. Then MerCathode controller is not functioning properly and should be replaced.

MERCATHODE MONITOR (C-91-68086A1)

DESCRIPTION

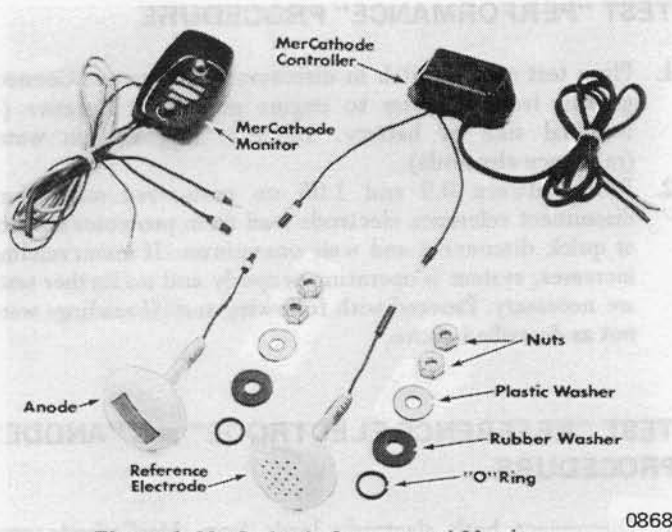


Figure 4. MerCathode System and Monitor

MerCathode Monitor consists of a signal light, control panel, push button and wiring harness assembly. (Figure 4) Its purpose is to confirm (by displaying a green light) that the MerCathode System is providing protective current.

IMPORTANT: MerCathode Monitor green light may not illuminate, or may only flicker when red button is depressed, if monitor is installed on boat with new MerCruiser drive unit. Protective Quicksilver black paint and new sacrificial zincs are protection enough and the MerCathode anode is not called upon to protect, as little or no galvanic corrosion is realized. As paint coating begins to deteriorate and zinc begins to sacrifice, the MerCathode is called upon to start its protection process. At this point, the green light indicates that the Monitor is functioning. MerCathode Tester (C-91-46802A1) may be used to test MerCathode System, if necessary.

INSTALLATION

1. For permanent installation, install MerCathode Monitor panel in convenient location.
2. Connect ground lead to suitable ground on instrument panel, engine or negative (-) battery terminal.
3. One of the monitor's polarized leads is color-banded with a yellow ring. This lead is coupled with the controller lead, which also has a yellow ring. Remaining monitor lead is connected to anode. No change is required in the basic MerCathode hookup, except that the monitor is series-inserted between controller and anode. (Figures 2 and 3)
4. Push button. If MerCathode is working properly, monitor green light will illuminate. If monitor does not light MerCathode is defective.

QUICKSILVER ISOLATOR

DESCRIPTION

The Quicksilver Isolator prevents flow of destructive galvanic current thru green grounding lead of power cable while maintaining safety feature provided by this lead. Although Isolator prevents accelerated corrosion, it provides no cathodic protection and must be supplemented by MerCathode System. (Figure 5)

A properly installed isolator will function trouble-free, and a simple test with a VOA Meter (C-91-52751) will check its proper operation.

NOTE: Replace the isolator if ohm readings are not within the range specified in the test procedure following.

TEST PROCEDURE

1. Set VOA Meter on Rx1 resistance scale.
2. Connect red test lead to one isolator lead. Connect black test lead to other isolator lead. Meter will swing full scale (0 ohms) and return to 27 ohms (plus-or-minus 4 ohms).
3. Reverse test leads. Meter again will swing full scale (0 ohms) and return to 27 ohms (plus-or-minus 4 ohms).
4. Connect red test lead to either isolator lead. Ground black test lead to isolator case. Meter will read infinite resistance.

INSTALLATION

CAUTION: Make sure that electrical power is disconnected from boat before installing Quicksilver Isolator.

1. Mount Quicksilver Isolator on boat close to electrical system distribution panel or buss in location providing air circulation.
2. Connect Quicksilver Isolator in series with incoming green safety grounding lead. (Figure 5)

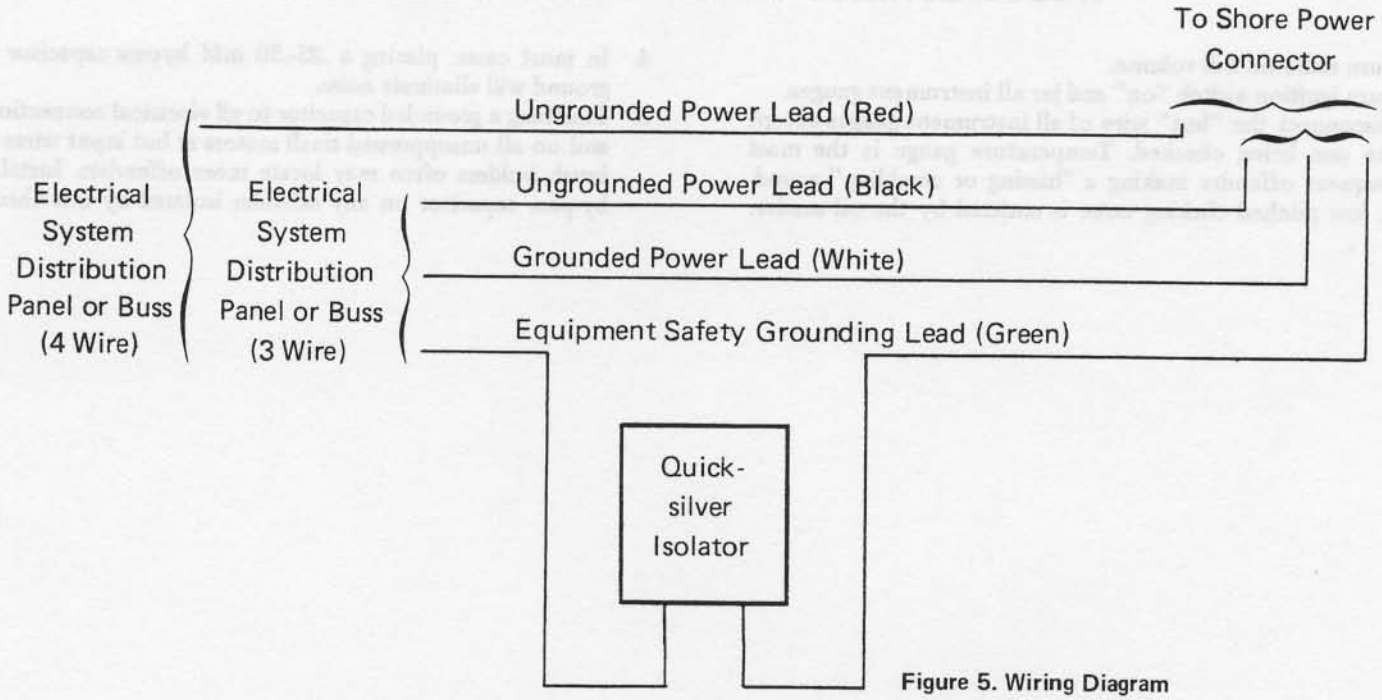


Figure 5. Wiring Diagram

MERCRUISER RADIO NOISE SUPPRESSION

DESCRIPTION

MerCruiser radio noise suppression kits are made of the finest equipment available for reduction of radio and electronic interference caused by ignition and alternator systems. When installed according to instructions, it will greatly reduce ignition and alternator interference. If radio interference is still experienced, refer to "Troubleshooting" Section 10.

PRECAUTIONS

The following precautions, regarding installation of radio receivers and other electronic equipment, may be helpful:

1. Install antenna as far as practicable from engine and remote control cables. Also, select an antenna suitable for the frequency on which it is intended to operate.
2. Antenna should be shielded and shield should be grounded.
3. All grounds should terminate at one point in order to avoid forming a ground loop circuit.
4. Condition of breaker points plays an important role in preventing marginal ignition performance, as a completely suppressed ignition system would be less tolerable of breaker point neglect. Breaker points, that are well maintained, help decrease any possible noise signals and also provide the utmost in engine performance.
5. Receiver-transmitter voltage must be taken directly from the battery. Tapping into accessory ignition switch will result in feedback and intercoupling, thus causing interference between electrical system and radio circuit.
6. Alternator brushes ride directly on slip rings. If noises, similar to direct current generator "whine", are experienced, check brush contact and clean slip rings.

SERVICING RADIO NOISE SUPPRESSION KITS

Under no circumstance should shielded cables be pierced, as this will short cables to ground and damage them. To make connections to spark plugs for timing or scope readings, use adaptor lead C-91-39212.

Spark plug cables are not to be repaired and require replacement if defective or damaged.

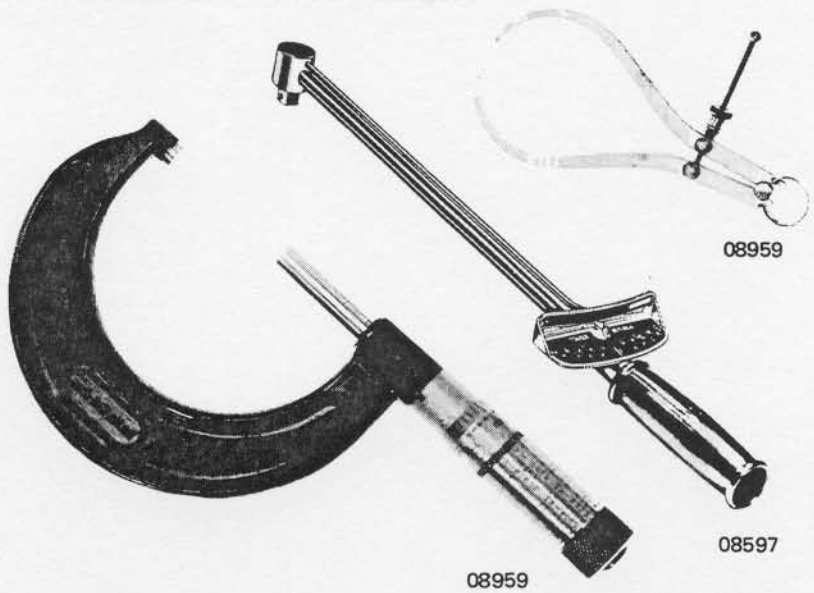
INSTRUMENT INTERFERENCE CHECK

1. Turn radio on full volume.
2. Turn ignition switch "on" and jar all instrument gauges.
3. Disconnect the "hot" wire of all instrument gauges except the one being checked. Temperature gauge is the most frequent offender making a "hissing or crackling" sound. A low pitched clicking noise is emitted by the oil sender.
4. In most cases, placing a .25-.50 mfd bypass capacitor to ground will eliminate noise.
5. Touching a grounded capacitor to all electrical connections and on all unsuppressed small motors at hot input wires or brush holders often may locate more offenders. Install a by-pass capacitor on any offender isolated by this check.

SPECIFICATIONS

MERCRUISER

Section 8



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SECTION 8 - SPECIFICATIONS

PART A - TUNE-UP and GENERAL

A BRUNSWICK COMPANY

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TUNE-UP SPECIFICATIONS
IN-LINE STERN DRIVE ENGINES

Model	120	140	165	470
Horsepower	120	140	165	170
Cu. In. Displacement	153 (2507cc)	181 (2966cc)	250 (4097cc)	224 (3671cc)
No. of Cyls.	4	4	6	4
Bore	3.87" (98.3mm)	4.00" (101.6mm)	3.87" (98.3mm)	4.36" (11.07cm)
Stroke	3.25" (82.6mm)	3.60" (91.4mm)	3.53" (89.7mm)	3.75" (95.3mm)
Compression Ratio	8.5 to 1	8.5 to 1	8 to 1	8.8 to 1
Compression Pressure (Note 3)	140 psi (9.8kg/cm²)	140 psi (9.8kg/cm²)	140 psi (9.8kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.022 (.559mm)	.022 (.559mm)	.016 (.406mm)	.022 (.559mm)
Point Dwell	31°-34°	31°-34°	31°-34°	31°-34°
Point Spring Tension	19-23 Oz. (.54-.65kg)	19-23 Oz. (.54-.65kg)	19-23 Oz. (.54-.65kg)	19-23 Oz. (.54-.65kg)
Spark Plug Type(s)	AC-MR43-T Champion RBL-8	AC-MR43-T Champion RBL-8	AC-MR43-T Champion RBL-8	AC-R42-TS Champion RBL-9Y
Plug Gap	.035 (.89mm)	.035 (.89mm)	.035 (.89mm)	.035 (.89mm)
Timing at Idle RPM	8° BTDC	6° BTDC	6° BTDC	8° BTDC
Max RPM at WOT	3900-4300	4200-4600	3900-4300	3800-4200
Idle RPM (in Gear)	650-700	650-700	650-700	650-700
Firing Order	(Figure 1)	(Figure 1)	(Figure 2)	(Figure 1)
Fuel Required	← (Note 4) →			
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →			
Battery Rating	← Reserve Capacity Rating of 100 Minutes →			
Oil Pressure at 2000 RPM	30-60 psi (2.11-4.22kg/cm²)	30-60 psi (2.11-4.22kg/cm²)	30-60 psi (2.11-4.22kg/cm²)	30-55 psi (2.11-3.85kg/cm²)
Oil Pan Capacity w/Filter	4 Qts. (3.8 Liters)	4 Qts. (3.8 Liters)	5 Qts. (4.7 Liters)	5.5 Qts. (5.2 Liters)
Alternator Rating	42 Amp	42 Amp	42 Amp	42 Amp
Valve Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash	N.A.

TUNE-UP SPECIFICATIONS V-8 STERN DRIVE ENGINES

Model	888 and 225-S	898	225-TR	228 and 228-TR	233
Horsepower	188 (888) 225 (225-S)	198	225	228	233
Cu. In. Displacement	302 (4949cc)	305 (4998cc)	302 (4949cc)	305 (4998cc)	351 (5752cc)
No. of Cyls.	8	8	8	8	8
Bore	4.00" (10.16cm)	3.74" (94.9mm)	4.00" (10.16cm)	3.74" (94.9mm)	4.00" (10.16cm)
Stroke	3.00" (76mm)	3.48" (88.4mm)	3.00" (76mm)	3.48" (88.4mm)	3.50" (89mm)
Compression Ratio	8 to 1	8.5 to 1	8 to 1	8.5 to 1	8 to 1
Compression Pressure (Note 3)	140 psi (9.8kg/cm²)	155 psi (10.9kg/cm²)	150 psi (10.5kg/cm²)	155 psi (10.9kg/cm²)	140 psi (9.8kg/cm²)
Point Gap	.016 - .021 (.406 - .533mm)	.016 - .019 (.406 - .482mm)	.016 - .021 (.406 - .533mm)	.016 - .019 (.406 - .482mm)	.016 - .021 (.406 - .533mm)
Point Dwell	26°-31°	26°-31°	26°-31°	26°-31°	26°-31°
Point Spring Tension	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)
Spark Plug Type(s)	(Note 5)	AC-MR43T Champion RBL-8	AC-C83T or Champion F-10	AC-MR43T Champion RBL-8	(Note 5)
Plug Gap	.030 (.76mm)	.035 (.89mm)	.030 (.76mm)	.035 (.89mm)	.030 (.76mm)
Timing at Idle RPM	10° BTDC	8° BTDC	10° BTDC	8° BTDC	10° BTDC
Max RPM at WOT	3800-4200	3800-4200	3800-4200	Note 8	3800-4200
Idle RPM (in Gear)	(Note 6)	650-700	550-600	650-700	(Note 7)
Firing Order	(Figure 5)	(Figure 3)	(Figure 5)	(Figure 3)	(Figure 5)
Fuel Required	← (Note 4) →				
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →				
Battery Rating	← Reserve Capacity Rating of 100 Minutes →				
Oil Pressure at 2000 RPM	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)
Oil Pan Capacity w/Filter	6 Qts. (5.7 Liters)	5 Qts. (4.73 Liters)	6 Qts. (5.7 Liters)	5 Qts. (4.73 Liters)	5 Qts. (4.73 Liters)
Alternator Rating	42 Amp	42 Amp	42 Amp	42 Amp	42 Amp
Valve Lash	N.A.	3/4 Turn Down from "O" Lash	N.A.	3/4 Turn Down from "O" Lash	N.A.

TUNE-UP SPECIFICATIONS
V-8 STERN DRIVE ENGINES (Continued)

Model	250	255-TR (Serial No. 4175499 and Below) and 255-TRS	255-TR (Serial No. 4175500 and Up) and 280-TRS	330-TR and 330-TRS
Horsepower	250	255	(255) 255 (280) 280	330
Cu. In. Displacement	350 (5735cc)	351 (5752cc)	350 (5735cc)	454 (7440cc)
No. of Cyls.	8	8	8	8
Bore	4.00" (10.16cm)	4.00" (10.16cm)	4.00" (10.16cm)	4.25" (10.8cm)
Stroke	3.48" (88.4mm)	3.50" (89mm)	3.48" (88.4mm)	4.00" (10.16cm)
Compression Ratio	8.7 to 1	8 to 1	8.8 to 1	8.2 to 1
Compression Pressure (Note 3)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.016-.019 (.406-.482mm)	.016-.021 (.406-.533mm)	.016-.019 (.406-.482mm)	.016-.019 (.406-.482mm)
Point Dwell	26°-31°	26°-31°	26°-31°	26°-31°
Point Spring Tension	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)
Spark Plug Type(s)	AC-MR43T Champion RBL-8	AC-C83T or Champion F-82	AC-MR43T Champion RBL-11Y	AC-MR43T Champion RBL-8
Plug Gap	.035 (.89mm)	.030 (.76mm)	.035 (.89mm)	.035 (.89mm)
Timing at Idle RPM	8° BTDC	10° BTDC	(255) 8° BTDC (280) 6° BTDC	10° BTDC
Max RPM at WOT	4200-4600	3800-4200	(255) 3800-4200 (280) 4600-5000	Note 9
Idle RPM (in Gear)	650-700	550-600	(255) 650-700 (280) 850-900	650-700
Firing Order	(Figure 3)	(Figure 5)	(Figure 3)	(Figure 3)
Fuel Required	← (Note 4) →			
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →			
Battery Rating	← Reserve Capacity Rating of 100 Minutes →			
Oil Pressure at 2000 RPM	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.7kg/cm²)	30-70 psi (2.1-4.9kg/cm²)
Oil Pan Capacity w/Filter	5 Qts. (4.7 Liters)	5 Qts. (4.7 Liters)	5 Qts. (4.7 Liters)	6 Qts. (5.7 Liters)
Alternator Rating	42 Amp	42 Amp	42 Amp	42 Amp
Valve Lash	3/4 Turn Down from "O" Lash	N.A.	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash

TUNE-UP SPECIFICATIONS
INBOARD and JET ENGINES

Model	198	225	228	233	255 (Serial No. 4178299 & Below)	255 (Serial No. .4178300 and Up)
Horsepower	198	225	228	233	255	255
Cu. In. Displacement	305 (4998cc)	302 (4949cc)	305 (4998cc)	351 (5752cc)	351 (5752cc)	350 (5735cc)
No. of Cyls.	8	8	8	8	8	8
Bore	3.74" (94.9mm)	4.00" (10.2cm)	3.74" (94.9mm)	4.00" (10.2cm)	4.00" (10.2cm)	4.00" (10.2cm)
Stroke	3.48" (88.4mm)	3.00" (76mm)	3.48" (88.4mm)	3.50" (89mm)	3.50" (89mm)	3.48" (88.4mm)
Compression Ratio	8.5 to 1	8 to 1	8.5 to 1	8 to 1	8 to 1	8.8 to 1
Compression Pressure (Note 3)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	155 psi (10.9kg/cm²)	140 psi (9.8kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.016-.019 (.406-.482mm)	.016-.021 (.406-.533mm)	.016-.019 (.406-.482mm)	.016-.021 (.406-.533mm)	.016-.021 (.406-.533mm)	.016-.019 (.406-.482mm)
Point Dwell	26°-31°	26°-31°	26°-31°	26°-31°	26°-31°	26°-31°
Point Spring Tension	25-30 Oz. (709-850 g)	17-21 Oz. (482-595 g)	25-30 Oz. (709-850 g)	17-21 Oz. (482-595 g)	17-21 Oz. (482-595 g)	25-30 Oz. (709-850 g)
Spark Plug Type(s)	AC-MR43T Champion RBL-8	AC-C83T or Champion F-10	AC-MR43T Champion RBL-8	AC-C83T or Champion F-10	AC-C83T or Champion F-10	AC-MR43T Champion RBL-11Y
Plug Gap	.035 (.89mm)	.030 (.76mm)	.035 (.89mm)	.030 (.76mm)	.030 (.76mm)	.035 (.89mm)
Timing at Idle RPM	8° BTDC	10° BTDC	8° BTDC	10° BTDC	10° BTDC	6° BTDC
Max RPM at WOT	3800-4200	3800-4200	3800-4200	3800-4200	3800-4200	3800-4200
Idle RPM (in Gear)	650-700	550-600	650-700	(Note 7)	550-600	650-700
Firing Order	(Figure 3 or 4)	(Figure 5 or 6)	(Figure 3 or 4)	(Figure 5 or 6)	(Figure 5 or 6)	(Figure 3 or 4)
Fuel Required	← (Note 4) →					
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →					
Battery Rating	← Reserve Capacity Rating of 100 Minutes →					
Oil Pressure at 2000 RPM	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.7kg/cm²)
Oil Pan Capacity w/Filter	Approx. 6 Qts. (5.7 Liters)	Approx. 6 Qts. (5.7 Liters)	Approx. 6 Qts. (5.7 Liters)	Approx. 7 Qts. (6.6 Liters)	Approx. 7 Qts. (6.6 Liters)	Approx. 6 Qts. (5.7 Liters)
Alternator Rating	42 Amps	42 Amps	42 Amps	42 Amps	42 Amps	42 Amps
Valve Lash	3/4 Turn Down from "O" Lash	N.A.	3/4 Turn Down from "O" Lash	N.A.	N.A.	3/4 Turn Down from "O" Lash

TUNE-UP SPECIFICATIONS
INBOARD and JET ENGINES
(Continued)

Model	330	350	Jet 400 Series
Horsepower	330	350	N.A.
Cu. In. Displacement	454 (7440cc)	454 (7440cc)	454 (7440cc)
No. of Cyls.	8	8	8
Bore	4.25" (10.8cm)	4.25" (10.8cm)	4.25" (10.8cm)
Stroke	4.00" (10.16cm)	4.00" (10.16cm)	4.00" (10.16cm)
Compression Ratio	8.2 to 1	8.5 to 1	8.6 to 1
Compression Pressure (Note 3)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.016-.019* (.406-.482mm)	N.A.	.016-.021 (.406-.533mm)
Point Dwell	26°-31°*	N.A.	26°-31°
Point Spring Tension	25-30 Oz.* (709-850 g)	N.A.	17-21 Oz. (.48-.59kg)
Spark Plug Type	(Note 10)	AC-MR41T	AC-MR43T
Plug Gap	.035 (.89mm)	.035 (.89mm)	.035 (.89mm)
Timing at Idle RPM	(Note 10)	8° BTDC	10° BTDC
Max RPM at WOT	3800-4200	3800-4200	4800-5200
Idle RPM (in Gear)	650-700	650-700	850-900
Firing Order	(Figure 3 or 4)	(Figure 3 or 4)	(Figure 3)
Fuel Required	(Note 4)		
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	12 Volt Negative Ground		
Battery Rating	Reserve Capacity Rating of 100 Minutes		
Oil Pressure at 2000 RPM	30-70 psi (2.1-4.9kg/cm²)	30-70 psi (2.1-4.9kg/cm²)	30-70 psi (2.1-4.9kg/cm²)
Oil Pan Capacity w/Filter	Approx. 7 Qts. (6.6 Liters)	Approx. 7 Qts. (6.6 Liters)	Approx. 6 Qts. (5.7 Liters)
Alternator Rating	42 Amps	42 Amps	42 Amps
Valve Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash

* - *Does Not Apply to Models with Thunderbolt Ignition.*

NOTES:

1. *Serial No. 3825578 and below use AC-CR44N*
2. *Serial No. 3826282 and below use AC-CR44N*
3. *Allowable variation 20 psi between compression readings of cylinders.*
4. *1974 and Older Models:*

CAUTION: Valve seat failure may occur from using lead-free or no-lead gasolines.

Use any good grade automotive regular leaded or premium gasoline with a minimum average octane rating of 88 (93 research). In areas where leaded premium and non-leaded regular are the only gasolines available, leaded premium should be used during the initial break-in period. Non-leaded regular gasoline may be used after the initial break-in is completed, provided a minimum of one tankfull of leaded gasoline is used after each four tankfulls of non-leaded gasoline.*

1975 and Newer Models: Use any good grade automotive regular leaded or non-leaded or premium gasoline with a minimum average octane rating of 88 (93 research).*

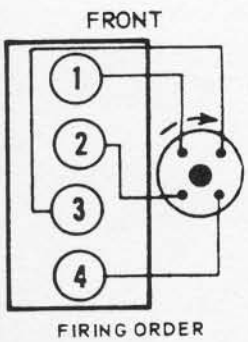
All Models: 86 average octane (90 research) leaded gasoline (with 0.5-4.0 grams lead per gallon) may be used if the gasoline described above is not available, however, the ignition timing must be retarded 4° to prevent harmful detonation.*

** U.S. Regulation requires posting average of research and motor octane.*

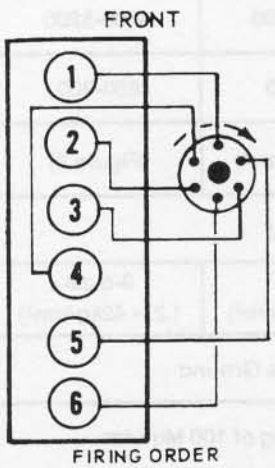
IMPORTANT: In countries outside the U.S.A. and Canada, consult your MerCruiser Distributor for the recommended gasoline in your area. The words, "Premium" and "Regular", have different significance in different countries.

5. *⅝ hex - 14mm plug - AC-MR43-T, except as follows: 888 (only), Serial No. 4615130-thru-4616217 and above 4616267, use AC-R42-T.*
   13/16 hex - 18mm plug - AC-CR83-T.
6. *888 (SN 4169596 and below) and all 225: 550-600 RPM; 888 (SN 4169597 and above): 650-700 RPM.*
7. *SN 4173767 and below: 550-600 RPM.*
   SN 4173768 and above: 650-700 RPM.
8. *MC 228: 4200-4600 RPM.*
   MC 228-TR: 3800-4200 RPM.
9. *TR Models: 3800-4200 RPM*
   TRS Models: 4200-4600 RPM.
10. *Models WITH Thunderbolt Ignition: Time @ 8° BTDC and use AC-R41T.*
    Models WITHOUT Thunderbolt Ignition: Time @ 10° BTDC and use AC-MR43-T.

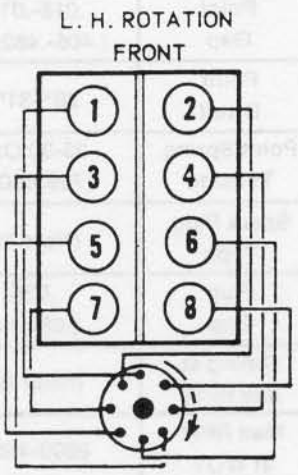
FIRING ORDER



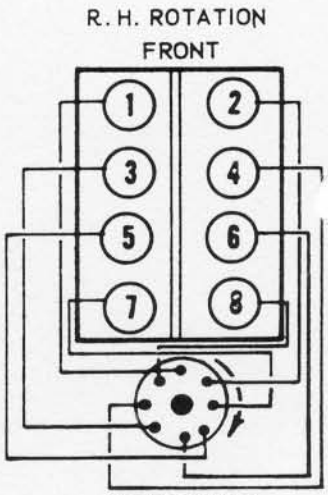
FIRING ORDER
1-3-4-2
Figure 1. GM



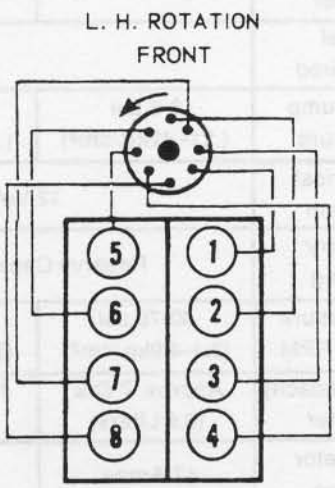
FIRING ORDER
1-5-3-6-2-4
Figure 2. GM



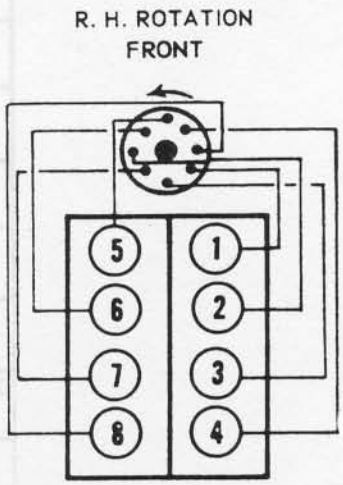
FIRING ORDER
1-8-4-3-6-5-7-2
Figure 3. GM



FIRING ORDER
1-2-7-5-6-3-4-8
Figure 4. GM



FIRING ORDER
1-3-7-2-6-5-4-8
Figure 5. Ford



FIRING ORDER
1-8-4-5-6-2-7-3
Figure 6. Ford

IGNITION SPECIFICATIONS

Engine Model	All Models with Standard Ignition		Models with Thunderbolt Ignition
Condenser	.18-.25 MFD		(Refer to "Thunderbolt Ignition Analyzer Test Manual" [C-90-62900]) §
Coil	Prestolite Coil Part No. 32193	Delco-Remy Coil Part No. 26433	
Coil Max. Operating Amps.	1.1*	.9*	
Coil Primary Resistance (Ohms) Minimum	1.1	.9	
Coil Primary Resistance (Ohms) Maximum	1.5 (OR)	1.2	
Coil Secondary Resistance (Ohms)	9,500-15,000	7,500-10,500	
Coil Secondary Continuity*	60-70*	53-63*	
Resistor Wire (Ohms)	1.8 - 2		
Spark Plug Type Spark Plug Gap Point Dwell Point Spring Tension Timing	Refer to "Tuneup Specifications".		

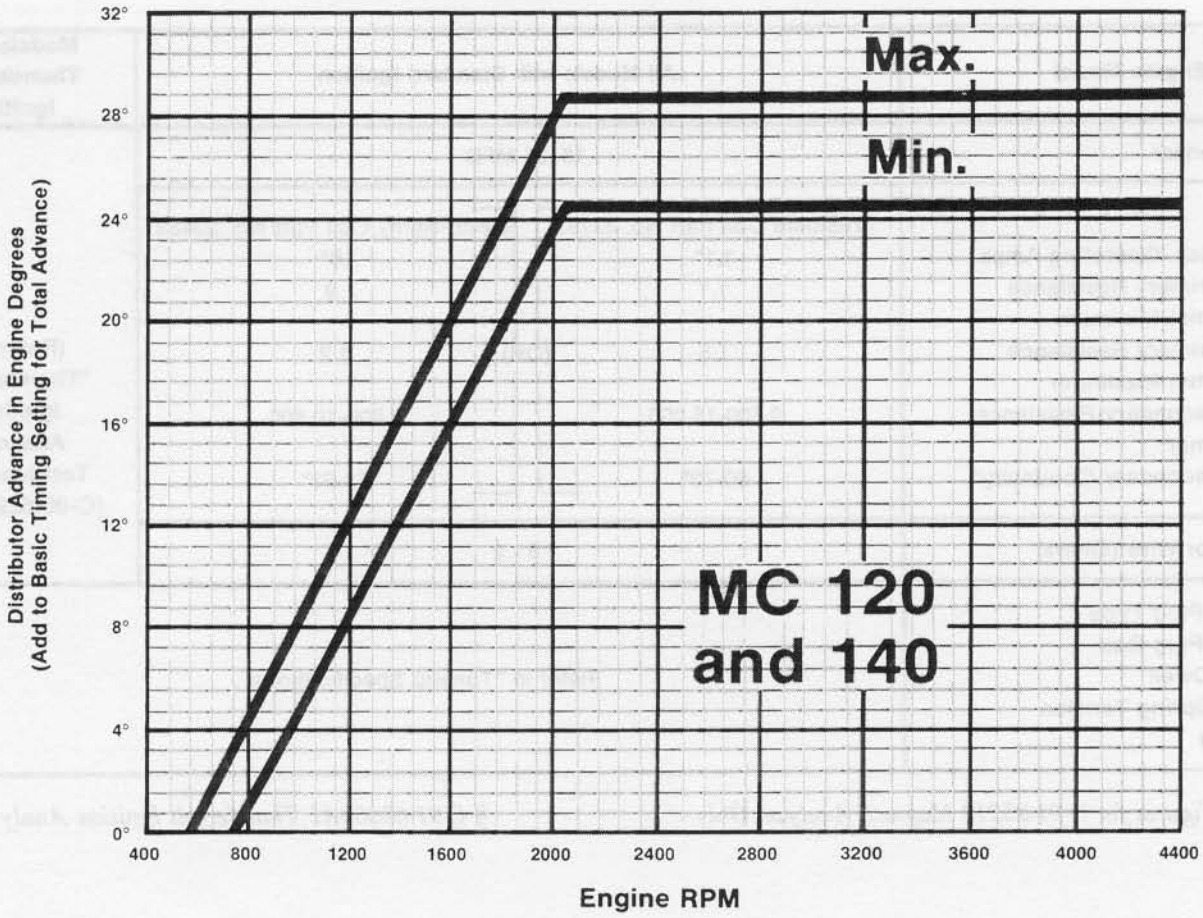
* *Figures for C-91-25213 Magneto Analyzer Only*

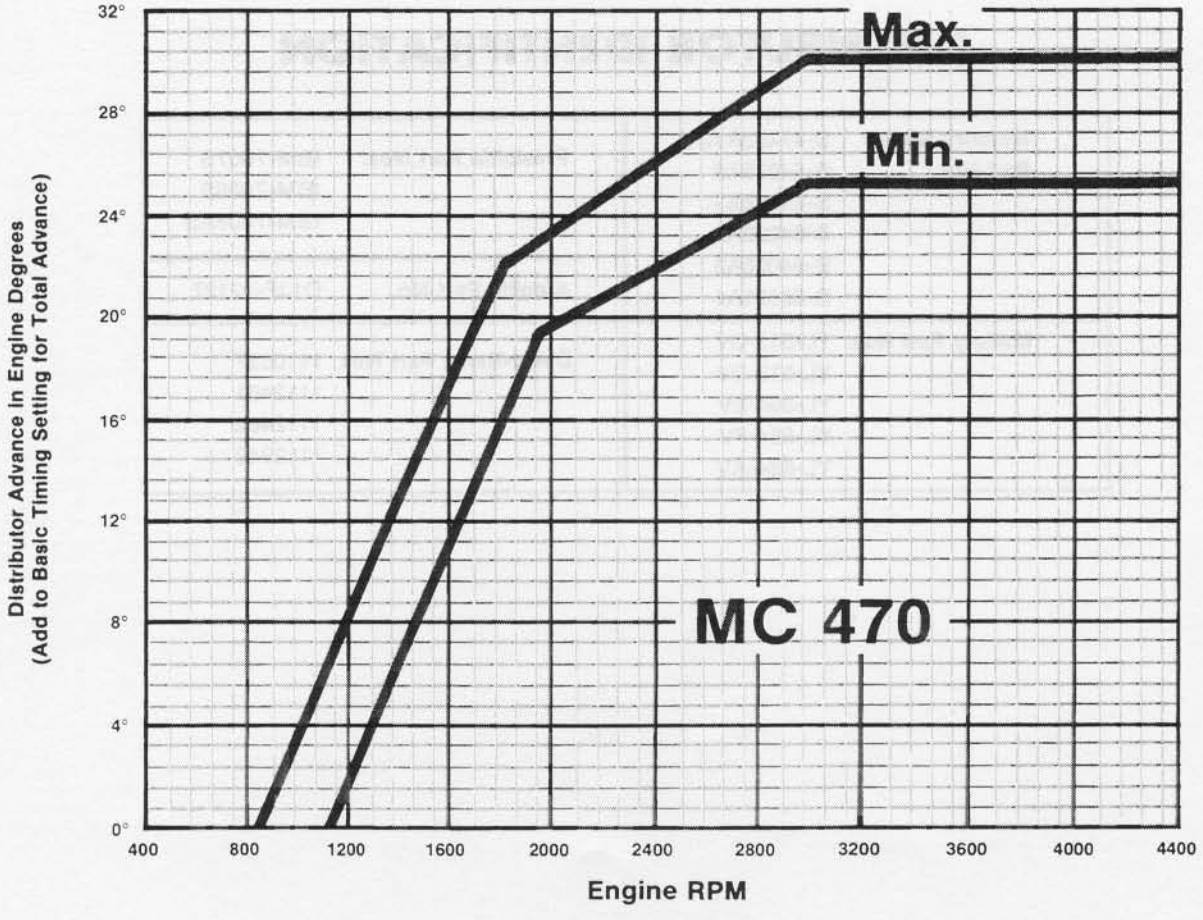
§ *C-91-62563A1 Thunderbolt Ignition Analyzer*

DISTRIBUTOR IDENTIFICATION

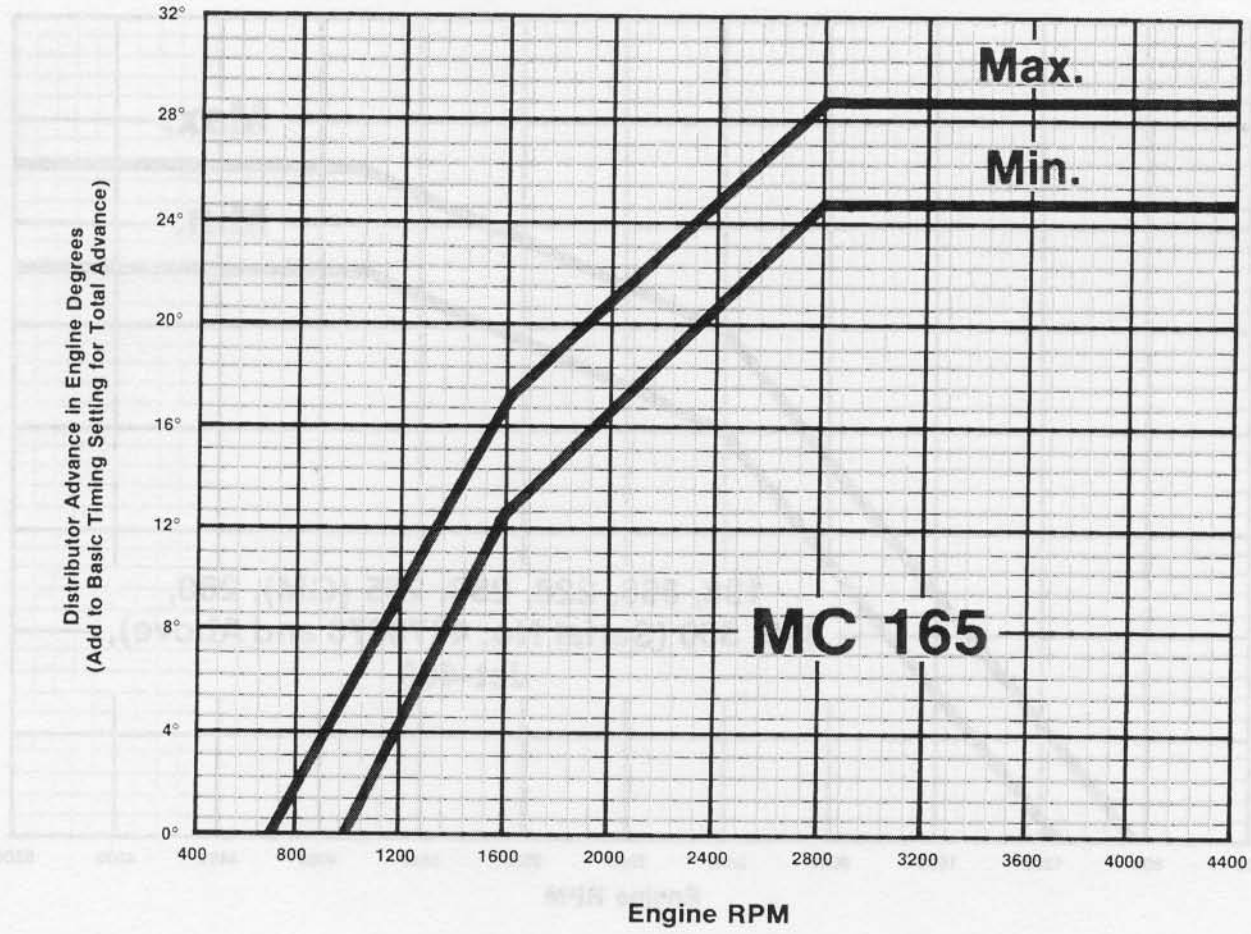
Mercury Marine Part Nos.	B-47493A12 B-64025A2 B-64025A3 B-64026A2 B-64026A3 B-68521A1	**Prestolite Part Nos.**	IBM-7007S IBM-7008S IBM-7008AS
		Autolite Part No.	D1JF-12127
Mallory Part Nos.	YL-512-CV YL-512-DV YL-554-EV YL-554-FV YL-624-AV	**Delco-Remy Part Nos.**	1110537 1112481 1112482 1112942

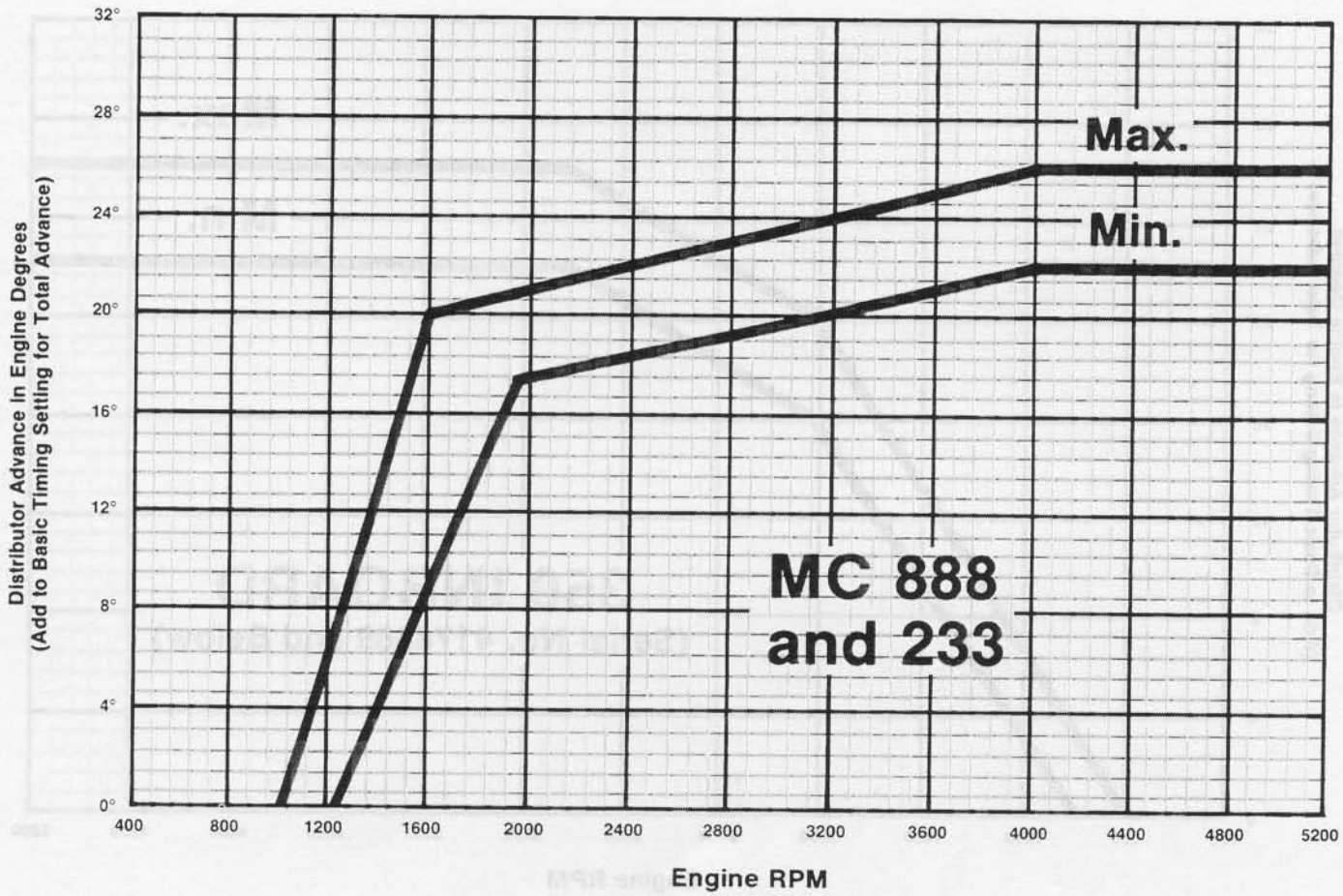
DISTRIBUTOR ADVANCE CURVES



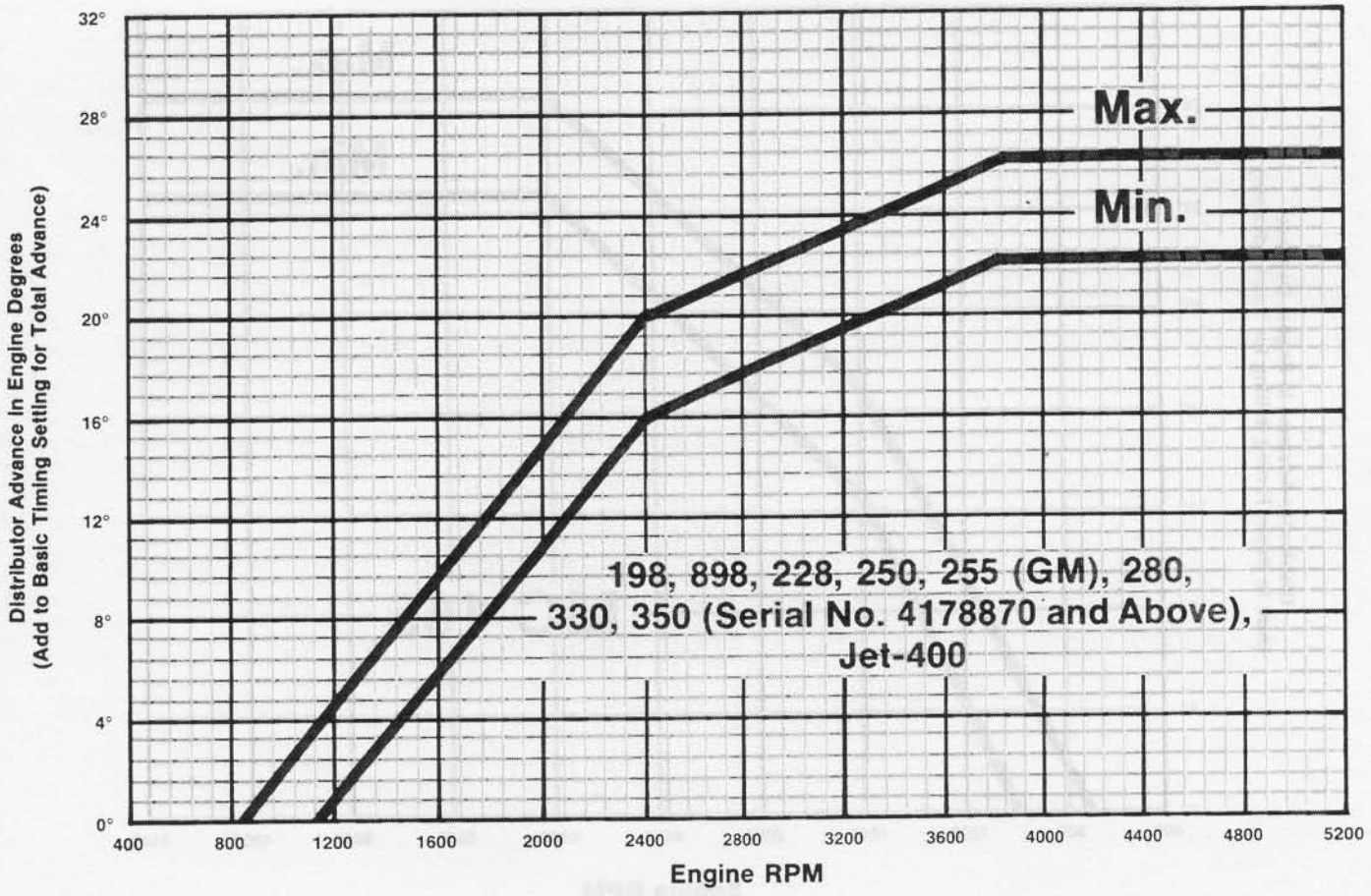


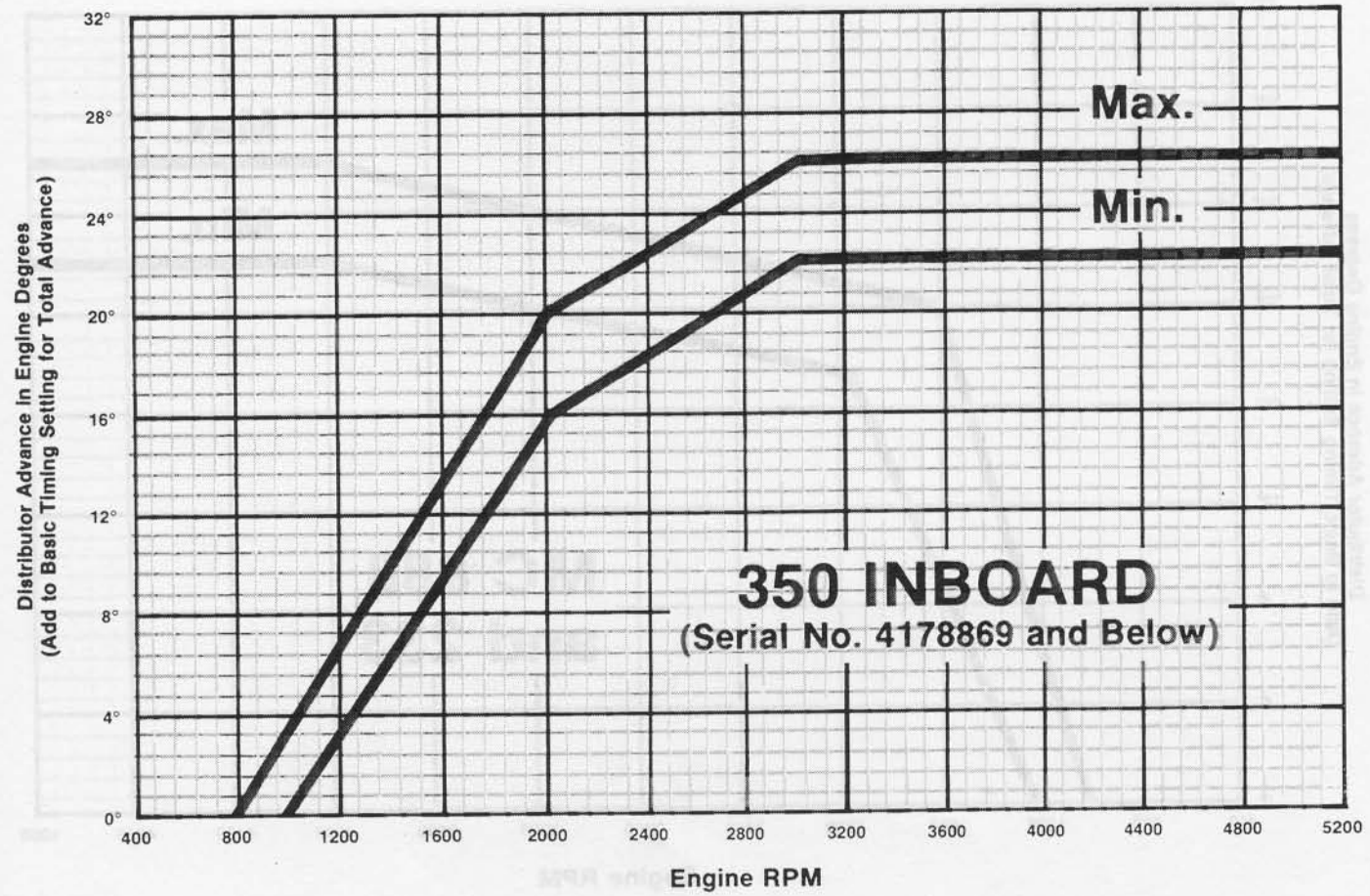
DISTRIBUTOR ADVANCE CURVES





DISTRIBUTOR ADVANCE CURVES





CARBURETOR SPECIFICATIONS

Engine Model	120-140	165	470	888-233	888	225-255	898-198	228	250	255-280	330	350	Jet 400
Carb. Model	2GC	2GC	2GV	2GV	Holley	Holley	2GV	4MV	4MV	4MV	4MV	4MV	4MV
Carb. No.	7043182 7044182 7043184	7043183	7045197 17057132	7044185 7044187 17056197	G317-1 (2 Bore)	6407 6576 (4 Bore)	17057139	17057282 17057283	17057298	7044291 7044290	17057299 17057287	7044286	7044287
Adjustment													
Float Level	5/8" (15.9mm)	5/8" (15.9mm)	11/16" (17.46mm)	19/32" (15.1mm)	Bottom of Sight Plug Hole ± 1/32" (.8mm)		19/32" (15.1mm)	15/64" (5.95mm)	15/64" (5.95mm)	.240" (6.1mm)	15/64" (5.95mm)	.240" (6.1mm)	.240" (6.1mm)
Float Drop	1-7/8" (47.6mm)	1-7/8" (47.6mm)	1-9/32" (32.54mm)	1-9/32" (32.54mm)	—	—	1-9/32" (32.54mm)	—	—	—	—	—	—
Pump Rod	.88" (22.35mm)	.952" (24.2mm)	1-7/32" (30.96mm)	1-3/16" (30.16mm)	.015" to .062" (.38 - 1.57mm)		1-5/32" (29.37mm)	13/32" (10.32mm)	13/32" (10.32mm)	.410" (10.4mm)	13/32" (10.32mm)	.410" (10.4mm)	.410" (10.4mm)
Vacuum Break	—	—	—	—	—	.110" (2.79mm)	—	5/32" (3.97mm)	5/32" (3.97mm)	.155" (3.94mm)	5/32" (3.97mm)	.155" (3.94mm)	.155" (3.94mm)
Air Valve Lockout	—	—	—	—	—	.015" (.38mm)	—	—	—	—	—	.003"-.015" (.08-.38mm)	.003"-.015" (.08-.38mm)
Air Valve Spring Windup	—	—	—	—	—	—	—	7/16 Turn	9/16 Turn	3/8 Turn	5/8 Turn	3/8 Turn	7/16 Turn
Choke Setting	Index Marks				Index Marks			—	See "Note" Below		—	See "Note" Below	
Prelim. Idle Mixture Setting	1-1/4 Turns	1-1/4 Turns	1-1/4 Turns	1-1/4 Turns	1-1/2 Turns	1-1/2 Turns	1-1/4 Turns	1 Turn	1 Turn	1 Turn	1 Turn	1 Turn	1 Turn

NOTE: One Rod Diameter Interference

ALTERNATOR SPECIFICATIONS

Manufacturer's Identification Number	Ground	Rotation	Field Current		Cold Output 5000 RPM	Hot Output
			Amperes	Volts		
1100576	Negative	Same as Engine	4.1-4.5	12	42 Amps	37 Amps
1102393			4.1-4.5	12	43 Amps	39 Amps
398-3631A2			N.A.	N.A.	17 Amps	16 Amps
			Permanent Magnet			
398-3631A4			N.A.	N.A.	43 Amps	41 Amps
			Permanent Magnet			
1102938			3.9-4.7	12	39 Amps	37 Amps
1102939			3.9-4.7	12	39 Amps	37 Amps
8MR2023F			2.9-3.4	12	39 Amps	37 Amps
8MR2024F			2.9-3.4	12	39 Amps	37 Amps

STARTER SPECIFICATIONS

Manufacturer's Identification Number	No Load Test					Brush Spring Tension
	Volts	Min. Amps.	Max. Amps.	Min. RPM	Max. RPM	
1108525 (Delco-Remy)	10.6	45	110	3,500	6,700	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
1108742 (Delco-Remy)	10.6	45	110	3,500	6,700	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
1108755 (Delco-Remy)	10.6	55	110	2,800	6,400	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
1108756 (Delco-Remy)	10.6	55	100	5,200	11,100	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
MEO 7003 (Prestolite)	Approx. 11	—	85	5,000	—	32-40 Oz. (.91-1.13kg) at Brush Spring Near Brush
MHA 7016 (Prestolite)	11	—	70	5,500	—	32-40 Oz. (.91-1.13kg) at Brush Spring Near Brush

CLOSED COOLING SYSTEM SPECIFICATIONS

Engine Model	Cooling System	Capacity (Qts.)	Cap Pressure (Lbs. Sq. In.)
MCM 120-140-165	B-61086A4	9 (8.5 Liters)	14 (.984kg/cm²)
MCM 470	Standard	10.5 (9.9 Liters)	14 (.984kg/cm²)
MCM 888	B-62472A3	17 (16.1 Liters)	14 (.984kg/cm²)
MCM 898-228-228TR-250 MIE 198-228-255	B-74643A1	20 (18.9 Liters)	14 (.984kg/cm²)
MCM 233	B-72114A1	22 (20.8 Liters)	14 (.984kg/cm²)
MCM 330TR(S)-MIE 330	B-63107A3	22 (20.8 Liters)	14 (.984kg/cm²)

Spark Plug Identification

(MerCruisers and Mercury Outboards)

(Spark Plugs Listed in Numerical Order by MerCruiser Part No.)

MerCruiser Part No.	AC Part No.	Champion Part No.	MerCruiser Stock Status*
C-33-20127		J-6J	Active
C-33-21375		J-8J	NLA
C-33-22265		XJ-6J	NLA
C-33-22805		J-7J	Active
C-33-28915	M44C		C-33-20127
C-33-28916	M45		C-33-22805
C-33-30578		J-4J	Active
C-33-30739		XJ-4J	NLA
C-33-31390	K421		NLA
C-33-31391	M44		NLA
C-33-32443		J-2J	NLA
C-33-33356	46N		C-33-54527
C-33-33743	C42-1		C-33-57953
C-33-34724	43N		NLA
C-33-37083	44F		Active
C-33-37405	C44N		C-33-54527
C-33-38216	C43		C-33-57953
C-33-39440		UL-18V	Active
C-33-39564	UJ-4J		NLA
C-33-39635	L-4J		C-33-53098
C-33-45191		L-19V	C-33-57451
C-33-46028		L-7J	C-33-48370
C-33-46082		L-9J	C-33-48368
C-33-46685	C44XL		Active
C-33-48325	V40N		C-33-57771
C-33-48368	M45FF		Active
C-33-48370	M43FF		Active
C-33-48372	V40		C-33-57769
C-33-53098	M42FF		Active
C-33-54527	CR44N		Active
C-33-54842	WR41N		Active
C-33-54844		RM-J3	C-33-54845
C-33-54845	WR42		Active
C-33-54980	(Autolite BTF-3M)		C-33-61783
C-33-55652	CR43		C-33-57953
C-33-55928	V40FF		C-33-58194
C-33-57451	V40FFM		Active
C-33-57769	V40K		Active
C-33-57771	V40NK		C-33-68546
C-33-57953	CR43K		Active
C-33-57955	42XL		Active
C-33-58194	V40FFK		Active
C-33-58195	R44T		C-33-59571
C-33-58362	SR83T		Active
C-33-59162	S41F		Active
C-33-59571	MR43T		Active
C-33-59599		L-77V	C-33-57451
C-33-59660	MR41T		Active
C-33-59804		D-77V	Active
C-33-60056	CR43N		Active
C-33-60816		RN-3	C-33-70779
C-33-60818	VR40FFM		C-33-68098
C-33-60917		L-78	Active
C-33-60919		L-81	Active
C-33-61783	C83T		Active
C-33-61976	M40FF		Active
C-33-63060		RL-78	Active
C-33-64053		F-10	Active
C-33-65591	QL-77V		C-33-68098
C-33-68057		L-76V	C-33-57451
C-33-68098		QL-76V	Active
C-33-68458		N-55G	Active
C-33-68546		N-19V	Active
C-33-70779	S42XLR		Active
C-33-70781	S43XLR		Active
C-33-72983		QL-7J/ QL-7J5	Not Stocked in U.S.
C-33-73271		QN-19V	Active
C-33-75340		RBL-9Y	Active
C-33-75739		QL-78V	Not Stocked in U.S.
C-33-76154		RBL-11Y	Active

* *If a Part No. is shown in this column, it supersedes the Part No. shown in Col. 1.* *NLA = No Longer Available*

NOTE: Refer to Page 8A-14 for cross-reference of AC or Champion Part Nos. to MerCruiser Part Nos.

HIGH ALTITUDE PERFORMANCE - MERCRUISER ENGINES

High altitude performance tests have shown that very little performance improvement is realized by increased spark advance or carburetor recalibration. On the contrary, reprop-ping the unit to run at its rated RPM has shown a significant increase in performance. Based on this testing, our general recommendation should be to "reprop the unit to its rated RPM in order to obtain maximum performance".

Any recommendation, other than changing props, to obtain rated RPM should be considered a special case and referred to the factory branch or area distributor for specific jet sizes and spark timing settings. These recommendations should not be made until the customer is fully aware of the following points:

1. Operating an engine with the above changes at lower elevation will cause engine failure.
2. Making the above changes (leaner jets and advance spark timing) will result in increased fuel economy, but will not have a significant effect on performance.

Spark Plug Cross-Reference

AC Part Number to MerCruiser Part Number

AC Part No.	MerCruiser Part No.
42XL	C-33-57955
43N	C-33-34724
44F	C-33-37083
46N	C-33-33356
C42-1	C-33-33743
C43	C-33-38216
C44N	C-33-37405
C44XL	C-33-46685
C83T	C-33-61783
CR43	C-33-55652
CR43K	C-33-57953
CR43N	C-33-60056
CR44N	C-33-54527
K421	C-33-31390
M40FF	C-33-61976
M42FF	C-33-53098
M43FF	C-33-48370
M44	C-33-31391
M44C	C-33-28915
M45	C-33-28916
M45FF	C-33-48368
MR41T	C-33-59660
MR43T	C-33-59571
R44T	C-33-58195
S41F	C-33-59162
S42XLR	C-33-70779
S43XLR	C-33-70781
SR83T	C-33-58362
V40	C-33-48372
V40FF	C-33-55928
V40FFM	C-33-57451
V40FFK	C-33-58194
V40K	C-33-57769
V40N	C-33-48325
V40NK	C-33-57771
VR40FFM	C-33-60818
WR41N	C-33-54842
WR42	C-33-54845

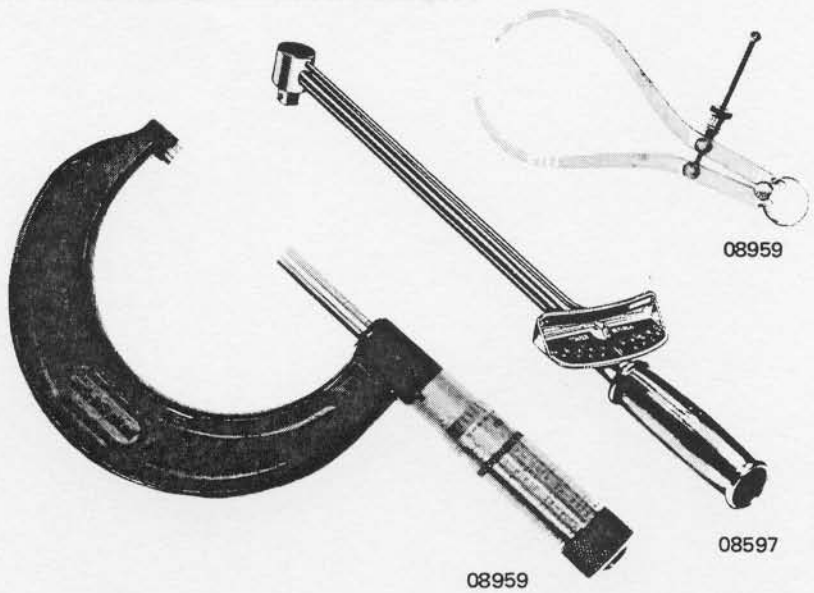
Champion Part Number to MerCruiser Part Number

Champion Part No.	MerCruiser Part No.
D-77V	C-33-59804
F-10	C-33-64053
J-2J	C-33-32443
J-4J	C-33-30578
J-6J	C-33-20127
J-7J	C-33-22805
J-8J	C-33-21375
L-4J	C-33-39635
L-7J	C-33-46028
L-9J	C-33-46082
L-19V	C-33-45191
L-76V	C-33-68057
L-77V	C-33-59599
L-78	C-33-60917
L-81	C-33-60919
N-19V	C-33-68546
N-55G	C-33-68458
QL-7J/QL-7J5	C-33-72983
QL-76V	C-33-68098
QL-77V	C-33-65591
QL-78V	C-33-75739
QN-19V	C-33-73271
RBL-9Y	C-33-75340
RBL-11Y	C-33-76154
RL-78	C-33-63060
RM-J3	C-33-54844
RN-3	C-33-60816
UJ-4J	C-33-39564
UL-18V	C-33-39440
XJ-4J	C-33-30739
XJ-6J	C-33-22265

SPECIFICATIONS

MERCRUISER

Section 8



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SECTION 8 - SPECIFICATIONS

PART A - TUNE-UP and GENERAL

A BRUNSWICK COMPANY

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TUNE-UP SPECIFICATIONS
IN-LINE STERN DRIVE ENGINES

Model	120	140	165	470
Horsepower	120	140	165	170
Cu. In. Displacement	153 (2507cc)	181 (2966cc)	250 (4097cc)	224 (3671cc)
No. of Cyls.	4	4	6	4
Bore	3.87" (98.3mm)	4.00" (101.6mm)	3.87" (98.3mm)	4.36" (11.07cm)
Stroke	3.25" (82.6mm)	3.60" (91.4mm)	3.53" (89.7mm)	3.75" (95.3mm)
Compression Ratio	8.5 to 1	8.5 to 1	8 to 1	8.8 to 1
Compression Pressure (Note 3)	140 psi (9.8kg/cm²)	140 psi (9.8kg/cm²)	140 psi (9.8kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.022 (.559mm)	.022 (.559mm)	.016 (.406mm)	.022 (.559mm)
Point Dwell	31°-34°	31°-34°	31°-34°	31°-34°
Point Spring Tension	19-23 Oz. (.54-.65kg)	19-23 Oz. (.54-.65kg)	19-23 Oz. (.54-.65kg)	19-23 Oz. (.54-.65kg)
Spark Plug Type(s)	AC-MR43-T Champion RBL-8	AC-MR43-T Champion RBL-8	AC-MR43-T Champion RBL-8	AC-R42-TS Champion RBL-9Y
Plug Gap	.035 (.89mm)	.035 (.89mm)	.035 (.89mm)	.035 (.89mm)
Timing at Idle RPM	8° BTDC	6° BTDC	6° BTDC	8° BTDC
Max RPM at WOT	3900-4300	4200-4600	3900-4300	3800-4200
Idle RPM (in Gear)	650-700	650-700	650-700	650-700
Firing Order	(Figure 1)	(Figure 1)	(Figure 2)	(Figure 1)
Fuel Required	← (Note 4) →			
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →			
Battery Rating	← Reserve Capacity Rating of 100 Minutes →			
Oil Pressure at 2000 RPM	30-60 psi (2.11-4.22kg/cm²)	30-60 psi (2.11-4.22kg/cm²)	30-60 psi (2.11-4.22kg/cm²)	30-55 psi (2.11-3.85kg/cm²)
Oil Pan Capacity w/Filter	4 Qts. (3.8 Liters)	4 Qts. (3.8 Liters)	5 Qts. (4.7 Liters)	5.5 Qts. (5.2 Liters)
Alternator Rating	42 Amp	42 Amp	42 Amp	42 Amp
Valve Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash	N.A.

TUNE-UP SPECIFICATIONS V-8 STERN DRIVE ENGINES

Model	888 and 225-S	898	225-TR	228 and 228-TR	233
Horsepower	188 (888) 225 (225-S)	198	225	228	233
Cu. In. Displacement	302 (4949cc)	305 (4998cc)	302 (4949cc)	305 (4998cc)	351 (5752cc)
No. of Cyls.	8	8	8	8	8
Bore	4.00" (10.16cm)	3.74" (94.9mm)	4.00" (10.16cm)	3.74" (94.9mm)	4.00" (10.16cm)
Stroke	3.00" (76mm)	3.48" (88.4mm)	3.00" (76mm)	3.48" (88.4mm)	3.50" (89mm)
Compression Ratio	8 to 1	8.5 to 1	8 to 1	8.5 to 1	8 to 1
Compression Pressure (Note 3)	140 psi (9.8kg/cm²)	155 psi (10.9kg/cm²)	150 psi (10.5kg/cm²)	155 psi (10.9kg/cm²)	140 psi (9.8kg/cm²)
Point Gap	.016 - .021 (.406 - .533mm)	.016 - .019 (.406 - .482mm)	.016 - .021 (.406 - .533mm)	.016 - .019 (.406 - .482mm)	.016 - .021 (.406 - .533mm)
Point Dwell	26°-31°	26°-31°	26°-31°	26°-31°	26°-31°
Point Spring Tension	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)
Spark Plug Type(s)	(Note 5)	AC-MR43T Champion RBL-8	AC-C83T or Champion F-10	AC-MR43T Champion RBL-8	(Note 5)
Plug Gap	.030 (.76mm)	.035 (.89mm)	.030 (.76mm)	.035 (.89mm)	.030 (.76mm)
Timing at Idle RPM	10° BTDC	8° BTDC	10° BTDC	8° BTDC	10° BTDC
Max RPM at WOT	3800-4200	3800-4200	3800-4200	Note 8	3800-4200
Idle RPM (in Gear)	(Note 6)	650-700	550-600	650-700	(Note 7)
Firing Order	(Figure 5)	(Figure 3)	(Figure 5)	(Figure 3)	(Figure 5)
Fuel Required	← (Note 4) →				
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →				
Battery Rating	← Reserve Capacity Rating of 100 Minutes →				
Oil Pressure at 2000 RPM	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)
Oil Pan Capacity w/Filter	6 Qts. (5.7 Liters)	5 Qts. (4.73 Liters)	6 Qts. (5.7 Liters)	5 Qts. (4.73 Liters)	5 Qts. (4.73 Liters)
Alternator Rating	42 Amp	42 Amp	42 Amp	42 Amp	42 Amp
Valve Lash	N.A.	3/4 Turn Down from "O" Lash	N.A.	3/4 Turn Down from "O" Lash	N.A.

TUNE-UP SPECIFICATIONS
V-8 STERN DRIVE ENGINES (Continued)

Model	250	255-TR (Serial No. 4175499 and Below) and 255-TRS	255-TR (Serial No. 4175500 and Up) and 280-TRS	330-TR and 330-TRS
Horsepower	250	255	(255) 255 (280) 280	330
Cu. In. Displacement	350 (5735cc)	351 (5752cc)	350 (5735cc)	454 (7440cc)
No. of Cyls.	8	8	8	8
Bore	4.00" (10.16cm)	4.00" (10.16cm)	4.00" (10.16cm)	4.25" (10.8cm)
Stroke	3.48" (88.4mm)	3.50" (89mm)	3.48" (88.4mm)	4.00" (10.16cm)
Compression Ratio	8.7 to 1	8 to 1	8.8 to 1	8.2 to 1
Compression Pressure (Note 3)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.016-.019 (.406-.482mm)	.016-.021 (.406-.533mm)	.016-.019 (.406-.482mm)	.016-.019 (.406-.482mm)
Point Dwell	26°-31°	26°-31°	26°-31°	26°-31°
Point Spring Tension	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)	25-30 Oz. (709-850 g)
Spark Plug Type(s)	AC-MR43T Champion RBL-8	AC-C83T or Champion F-82	AC-MR43T Champion RBL-11Y	AC-MR43T Champion RBL-8
Plug Gap	.035 (.89mm)	.030 (.76mm)	.035 (.89mm)	.035 (.89mm)
Timing at Idle RPM	8° BTDC	10° BTDC	(255) 8° BTDC (280) 6° BTDC	10° BTDC
Max RPM at WOT	4200-4600	3800-4200	(255) 3800-4200 (280) 4600-5000	Note 9
Idle RPM (in Gear)	650-700	550-600	(255) 650-700 (280) 850-900	650-700
Firing Order	(Figure 3)	(Figure 5)	(Figure 3)	(Figure 3)
Fuel Required	← (Note 4) →			
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →			
Battery Rating	← Reserve Capacity Rating of 100 Minutes →			
Oil Pressure at 2000 RPM	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.7kg/cm²)	30-70 psi (2.1-4.9kg/cm²)
Oil Pan Capacity w/Filter	5 Qts. (4.7 Liters)	5 Qts. (4.7 Liters)	5 Qts. (4.7 Liters)	6 Qts. (5.7 Liters)
Alternator Rating	42 Amp	42 Amp	42 Amp	42 Amp
Valve Lash	3/4 Turn Down from "O" Lash	N.A.	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash

TUNE-UP SPECIFICATIONS
INBOARD and JET ENGINES

Model	198	225	228	233	255 (Serial No. 4178299 & Below)	255 (Serial No. .4178300 and Up)
Horsepower	198	225	228	233	255	255
Cu. In. Displacement	305 (4998cc)	302 (4949cc)	305 (4998cc)	351 (5752cc)	351 (5752cc)	350 (5735cc)
No. of Cyls.	8	8	8	8	8	8
Bore	3.74" (94.9mm)	4.00" (10.2cm)	3.74" (94.9mm)	4.00" (10.2cm)	4.00" (10.2cm)	4.00" (10.2cm)
Stroke	3.48" (88.4mm)	3.00" (76mm)	3.48" (88.4mm)	3.50" (89mm)	3.50" (89mm)	3.48" (88.4mm)
Compression Ratio	8.5 to 1	8 to 1	8.5 to 1	8 to 1	8 to 1	8.8 to 1
Compression Pressure (Note 3)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	155 psi (10.9kg/cm²)	140 psi (9.8kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.016-.019 (.406-.482mm)	.016-.021 (.406-.533mm)	.016-.019 (.406-.482mm)	.016-.021 (.406-.533mm)	.016-.021 (.406-.533mm)	.016-.019 (.406-.482mm)
Point Dwell	26°-31°	26°-31°	26°-31°	26°-31°	26°-31°	26°-31°
Point Spring Tension	25-30 Oz. (709-850 g)	17-21 Oz. (482-595 g)	25-30 Oz. (709-850 g)	17-21 Oz. (482-595 g)	17-21 Oz. (482-595 g)	25-30 Oz. (709-850 g)
Spark Plug Type(s)	AC-MR43T Champion RBL-8	AC-C83T or Champion F-10	AC-MR43T Champion RBL-8	AC-C83T or Champion F-10	AC-C83T or Champion F-10	AC-MR43T Champion RBL-11Y
Plug Gap	.035 (.89mm)	.030 (.76mm)	.035 (.89mm)	.030 (.76mm)	.030 (.76mm)	.035 (.89mm)
Timing at Idle RPM	8° BTDC	10° BTDC	8° BTDC	10° BTDC	10° BTDC	6° BTDC
Max RPM at WOT	3800-4200	3800-4200	3800-4200	3800-4200	3800-4200	3800-4200
Idle RPM (in Gear)	650-700	550-600	650-700	(Note 7)	550-600	650-700
Firing Order	(Figure 3 or 4)	(Figure 5 or 6)	(Figure 3 or 4)	(Figure 5 or 6)	(Figure 5 or 6)	(Figure 3 or 4)
Fuel Required	← (Note 4) →					
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	← 12 Volt Negative Ground →					
Battery Rating	← Reserve Capacity Rating of 100 Minutes →					
Oil Pressure at 2000 RPM	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.85kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	40-70 psi (2.8-4.9kg/cm²)	30-55 psi (2.1-3.7kg/cm²)
Oil Pan Capacity w/Filter	Approx. 6 Qts. (5.7 Liters)	Approx. 6 Qts. (5.7 Liters)	Approx. 6 Qts. (5.7 Liters)	Approx. 7 Qts. (6.6 Liters)	Approx. 7 Qts. (6.6 Liters)	Approx. 6 Qts. (5.7 Liters)
Alternator Rating	42 Amps	42 Amps	42 Amps	42 Amps	42 Amps	42 Amps
Valve Lash	3/4 Turn Down from "O" Lash	N.A.	3/4 Turn Down from "O" Lash	N.A.	N.A.	3/4 Turn Down from "O" Lash

TUNE-UP SPECIFICATIONS
INBOARD and JET ENGINES
(Continued)

Model	330	350	Jet 400 Series
Horsepower	330	350	N.A.
Cu. In. Displacement	454 (7440cc)	454 (7440cc)	454 (7440cc)
No. of Cyls.	8	8	8
Bore	4.25" (10.8cm)	4.25" (10.8cm)	4.25" (10.8cm)
Stroke	4.00" (10.16cm)	4.00" (10.16cm)	4.00" (10.16cm)
Compression Ratio	8.2 to 1	8.5 to 1	8.6 to 1
Compression Pressure (Note 3)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)	150 psi (10.5kg/cm²)
Point Gap	.016-.019* (.406-.482mm)	N.A.	.016-.021 (.406-.533mm)
Point Dwell	26°-31°*	N.A.	26°-31°
Point Spring Tension	25-30 Oz.* (709-850 g)	N.A.	17-21 Oz. (.48-.59kg)
Spark Plug Type	(Note 10)	AC-MR41T	AC-MR43T
Plug Gap	.035 (.89mm)	.035 (.89mm)	.035 (.89mm)
Timing at Idle RPM	(Note 10)	8° BTDC	10° BTDC
Max RPM at WOT	3800-4200	3800-4200	4800-5200
Idle RPM (in Gear)	650-700	650-700	850-900
Firing Order	(Figure 3 or 4)	(Figure 3 or 4)	(Figure 3)
Fuel Required	(Note 4)		
Fuel Pump Pressure	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)	3-6 psi (.21-.42kg/cm²)
Electrical System	12 Volt Negative Ground		
Battery Rating	Reserve Capacity Rating of 100 Minutes		
Oil Pressure at 2000 RPM	30-70 psi (2.1-4.9kg/cm²)	30-70 psi (2.1-4.9kg/cm²)	30-70 psi (2.1-4.9kg/cm²)
Oil Pan Capacity w/Filter	Approx. 7 Qts. (6.6 Liters)	Approx. 7 Qts. (6.6 Liters)	Approx. 6 Qts. (5.7 Liters)
Alternator Rating	42 Amps	42 Amps	42 Amps
Valve Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash	3/4 Turn Down from "O" Lash

* - *Does Not Apply to Models with Thunderbolt Ignition.*

NOTES:

1. *Serial No. 3825578 and below use AC-CR44N*
2. *Serial No. 3826282 and below use AC-CR44N*
3. *Allowable variation 20 psi between compression readings of cylinders.*
4. *1974 and Older Models:*

CAUTION: Valve seat failure may occur from using lead-free or no-lead gasolines.

Use any good grade automotive regular leaded or premium gasoline with a minimum average octane rating of 88 (93 research). In areas where leaded premium and non-leaded regular are the only gasolines available, leaded premium should be used during the initial break-in period. Non-leaded regular gasoline may be used after the initial break-in is completed, provided a minimum of one tankfull of leaded gasoline is used after each four tankfulls of non-leaded gasoline.*

1975 and Newer Models: Use any good grade automotive regular leaded or non-leaded or premium gasoline with a minimum average octane rating of 88 (93 research).*

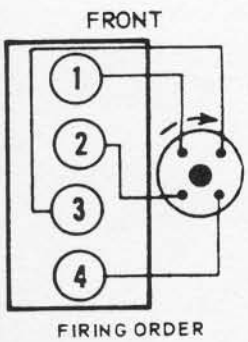
All Models: 86 average octane (90 research) leaded gasoline (with 0.5-4.0 grams lead per gallon) may be used if the gasoline described above is not available, however, the ignition timing must be retarded 4° to prevent harmful detonation.*

** U.S. Regulation requires posting average of research and motor octane.*

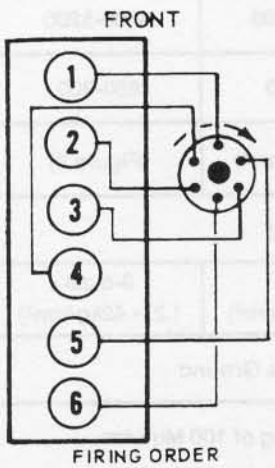
IMPORTANT: In countries outside the U.S.A. and Canada, consult your MerCruiser Distributor for the recommended gasoline in your area. The words, "Premium" and "Regular", have different significance in different countries.

5. *⅝ hex - 14mm plug - AC-MR43-T, except as follows: 888 (only), Serial No. 4615130-thru-4616217 and above 4616267, use AC-R42-T.*
   13/16 hex - 18mm plug - AC-CR83-T.
6. *888 (SN 4169596 and below) and all 225: 550-600 RPM; 888 (SN 4169597 and above): 650-700 RPM.*
7. *SN 4173767 and below: 550-600 RPM.*
   SN 4173768 and above: 650-700 RPM.
8. *MC 228: 4200-4600 RPM.*
   MC 228-TR: 3800-4200 RPM.
9. *TR Models: 3800-4200 RPM*
   TRS Models: 4200-4600 RPM.
10. *Models WITH Thunderbolt Ignition: Time @ 8° BTDC and use AC-R41T.*
    Models WITHOUT Thunderbolt Ignition: Time @ 10° BTDC and use AC-MR43-T.

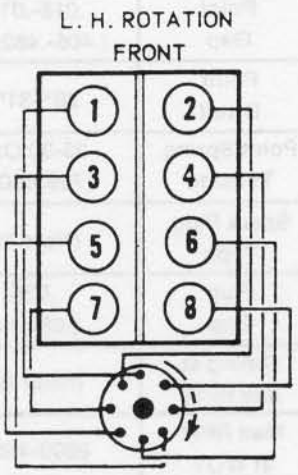
FIRING ORDER



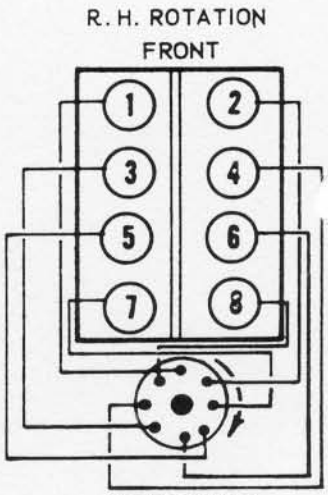
FIRING ORDER
1-3-4-2
Figure 1. GM



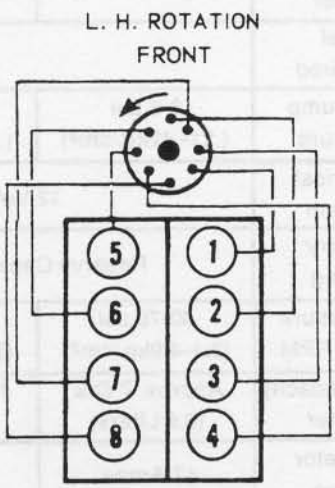
FIRING ORDER
1-5-3-6-2-4
Figure 2. GM



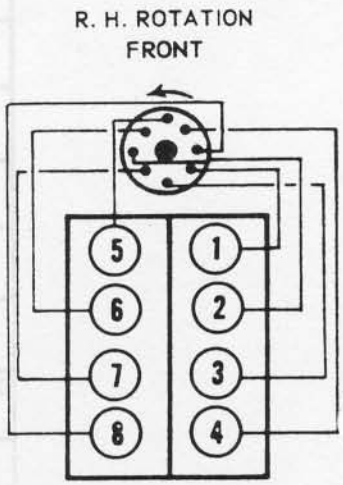
FIRING ORDER
1-8-4-3-6-5-7-2
Figure 3. GM



FIRING ORDER
1-2-7-5-6-3-4-8
Figure 4. GM



FIRING ORDER
1-3-7-2-6-5-4-8
Figure 5. Ford



FIRING ORDER
1-8-4-5-6-2-7-3
Figure 6. Ford

IGNITION SPECIFICATIONS

Engine Model	All Models with Standard Ignition		Models with Thunderbolt Ignition
Condenser	.18-.25 MFD		(Refer to "Thunderbolt Ignition Analyzer Test Manual" [C-90-62900]) §
Coil	Prestolite Coil Part No. 32193	Delco-Remy Coil Part No. 26433	
Coil Max. Operating Amps.	1.1*	.9*	
Coil Primary Resistance (Ohms) Minimum	1.1	.9	
Coil Primary Resistance (Ohms) Maximum	1.5 (OR)	1.2	
Coil Secondary Resistance (Ohms)	9,500-15,000	7,500-10,500	
Coil Secondary Continuity*	60-70*	53-63*	
Resistor Wire (Ohms)	1.8 - 2		
Spark Plug Type Spark Plug Gap Point Dwell Point Spring Tension Timing	Refer to "Tuneup Specifications".		

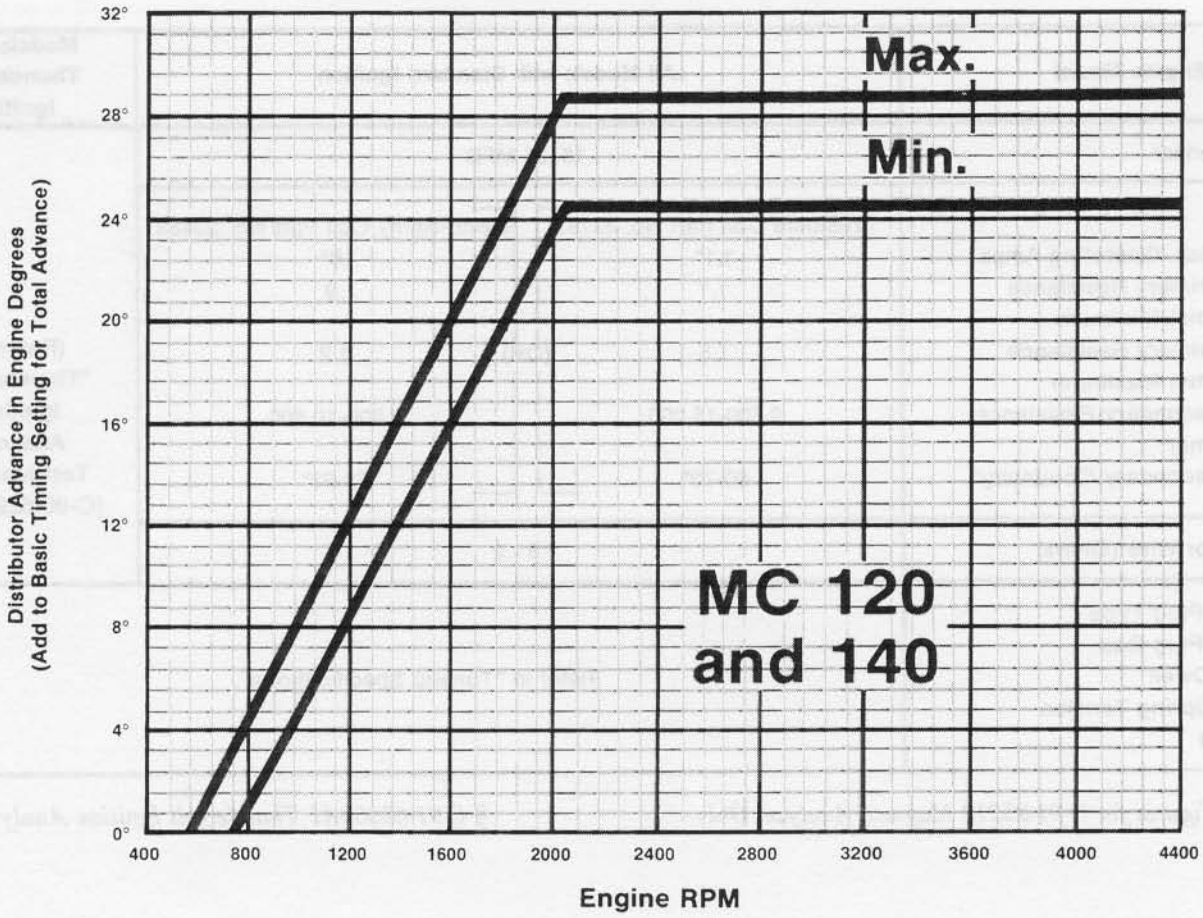
* *Figures for C-91-25213 Magneto Analyzer Only*

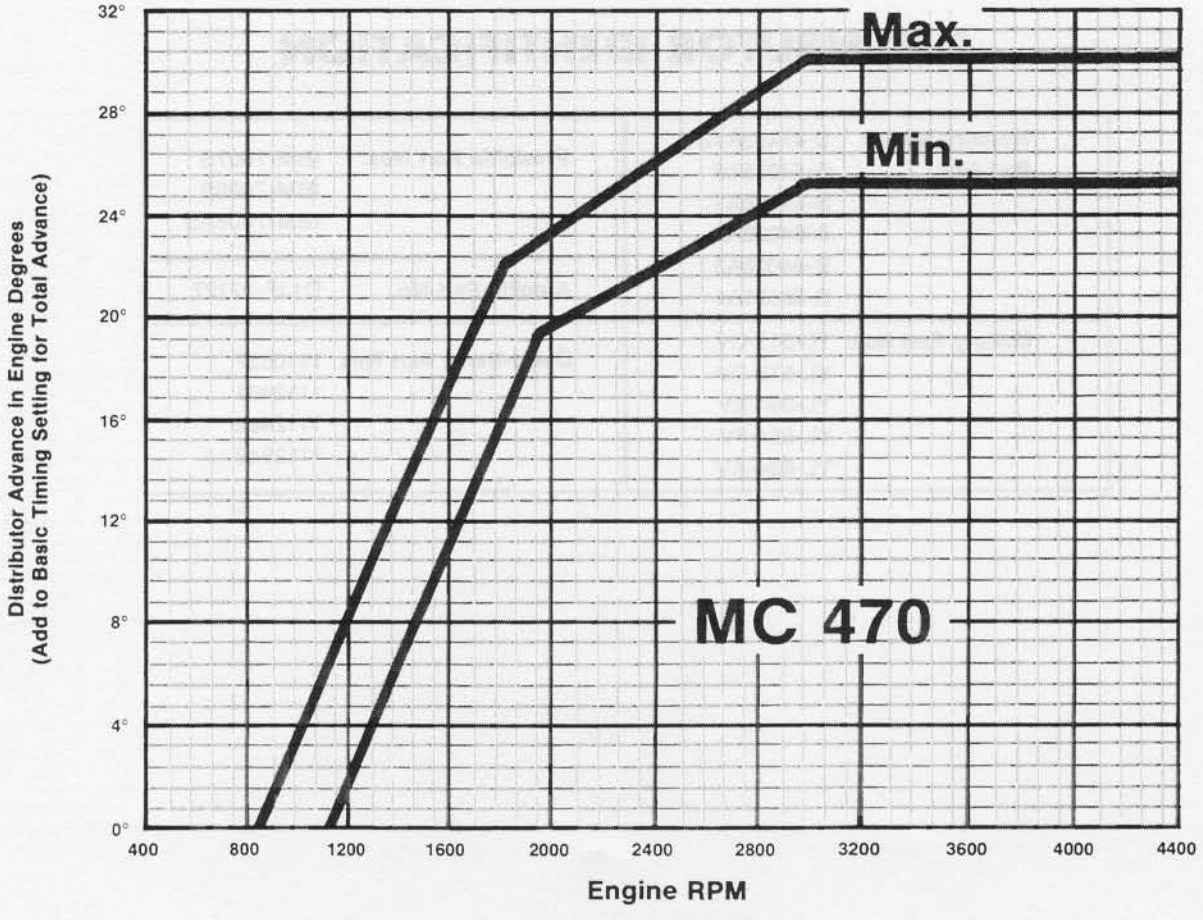
§ *C-91-62563A1 Thunderbolt Ignition Analyzer*

DISTRIBUTOR IDENTIFICATION

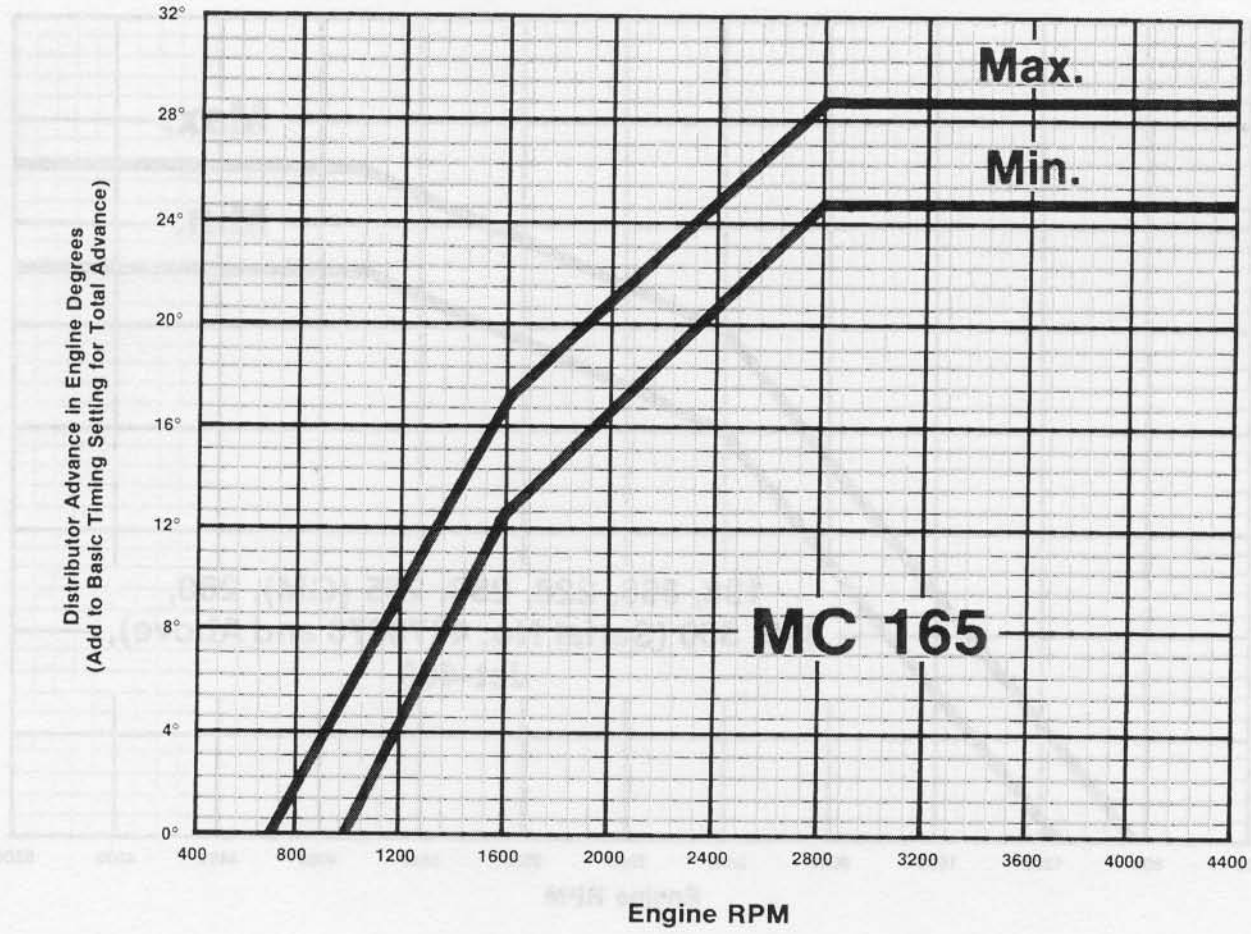
Mercury Marine Part Nos.	B-47493A12 B-64025A2 B-64025A3 B-64026A2 B-64026A3 B-68521A1	**Prestolite Part Nos.**	IBM-7007S IBM-7008S IBM-7008AS
		Autolite Part No.	D1JF-12127
Mallory Part Nos.	YL-512-CV YL-512-DV YL-554-EV YL-554-FV YL-624-AV	**Delco-Remy Part Nos.**	1110537 1112481 1112482 1112942

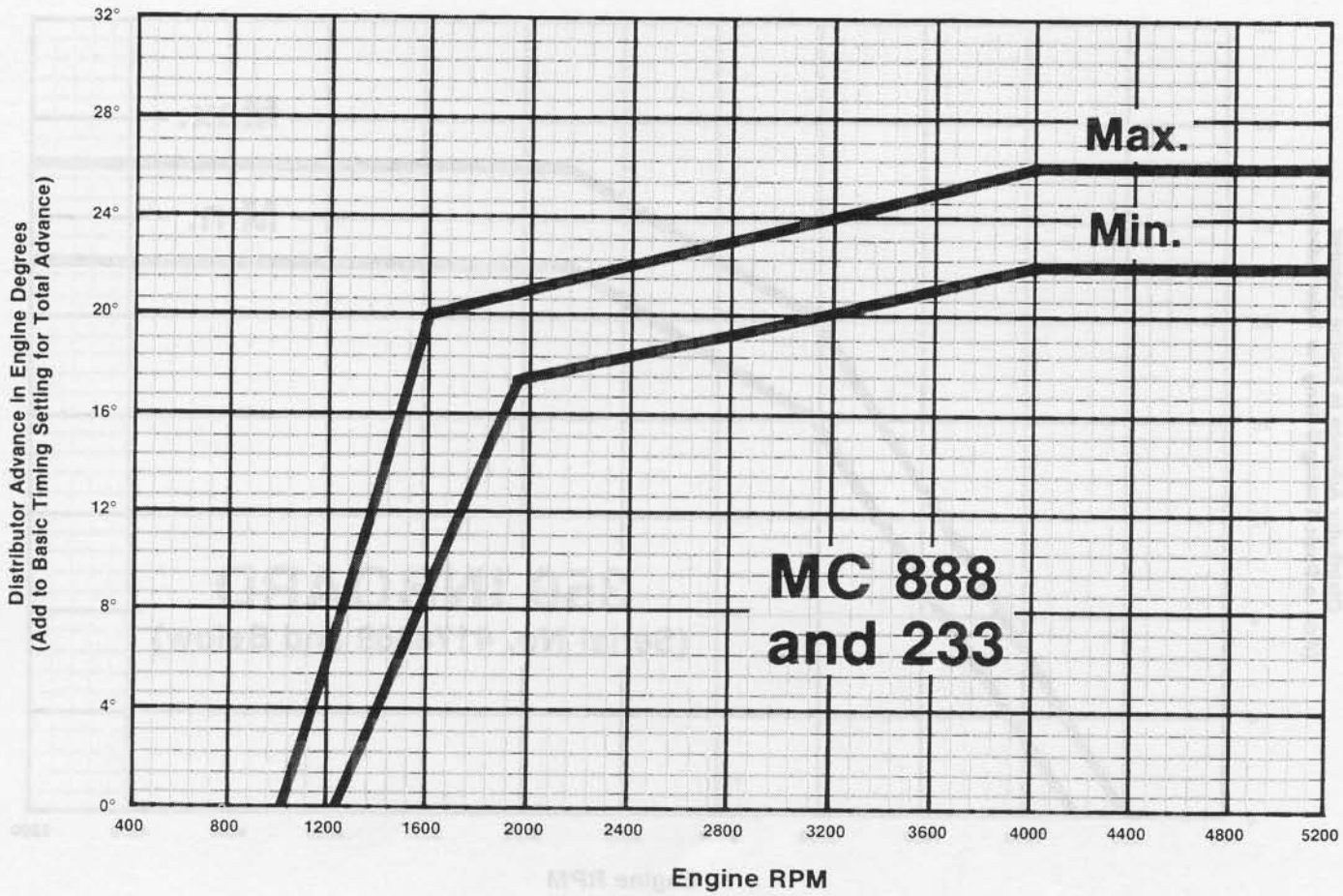
DISTRIBUTOR ADVANCE CURVES



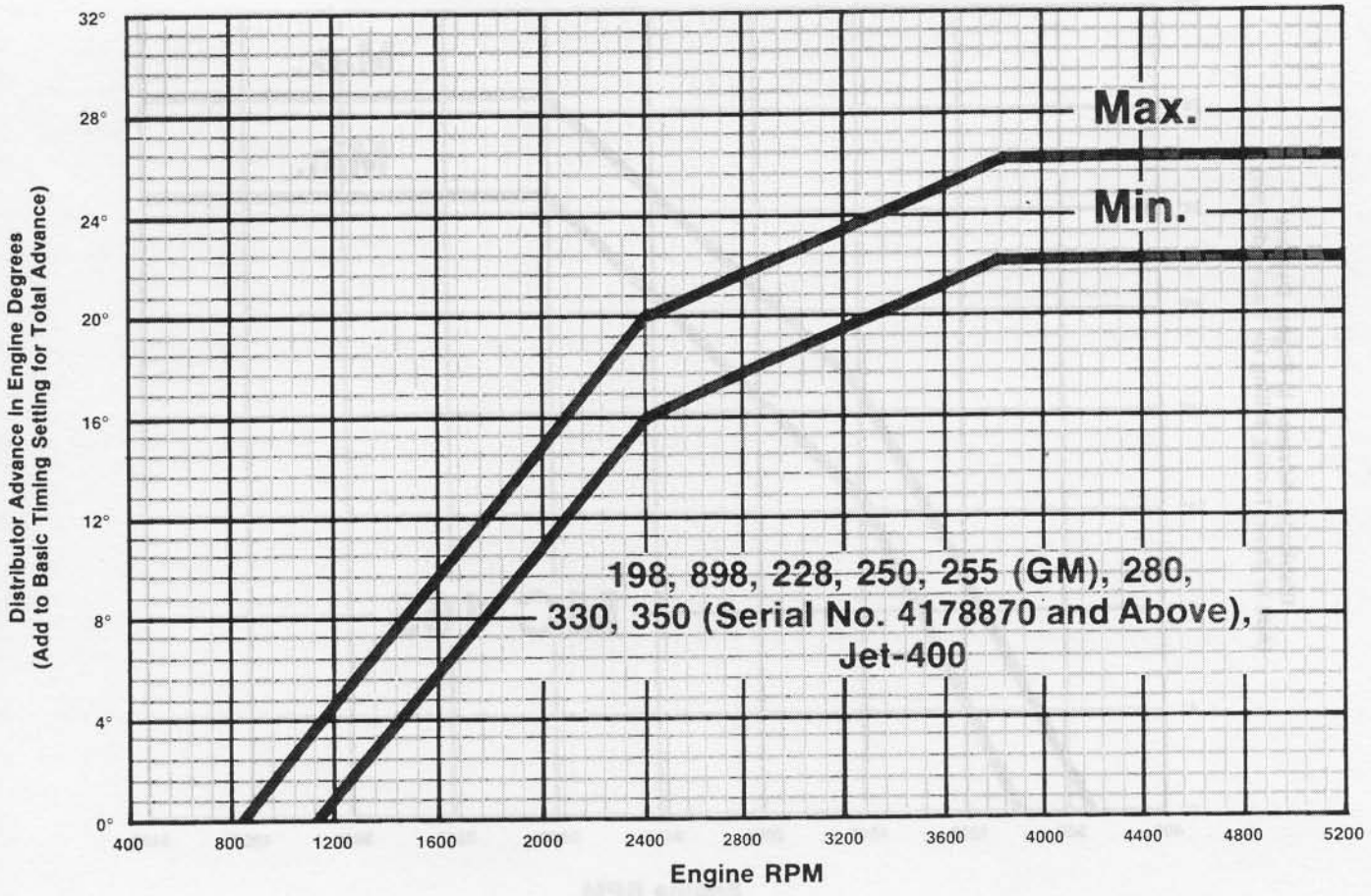


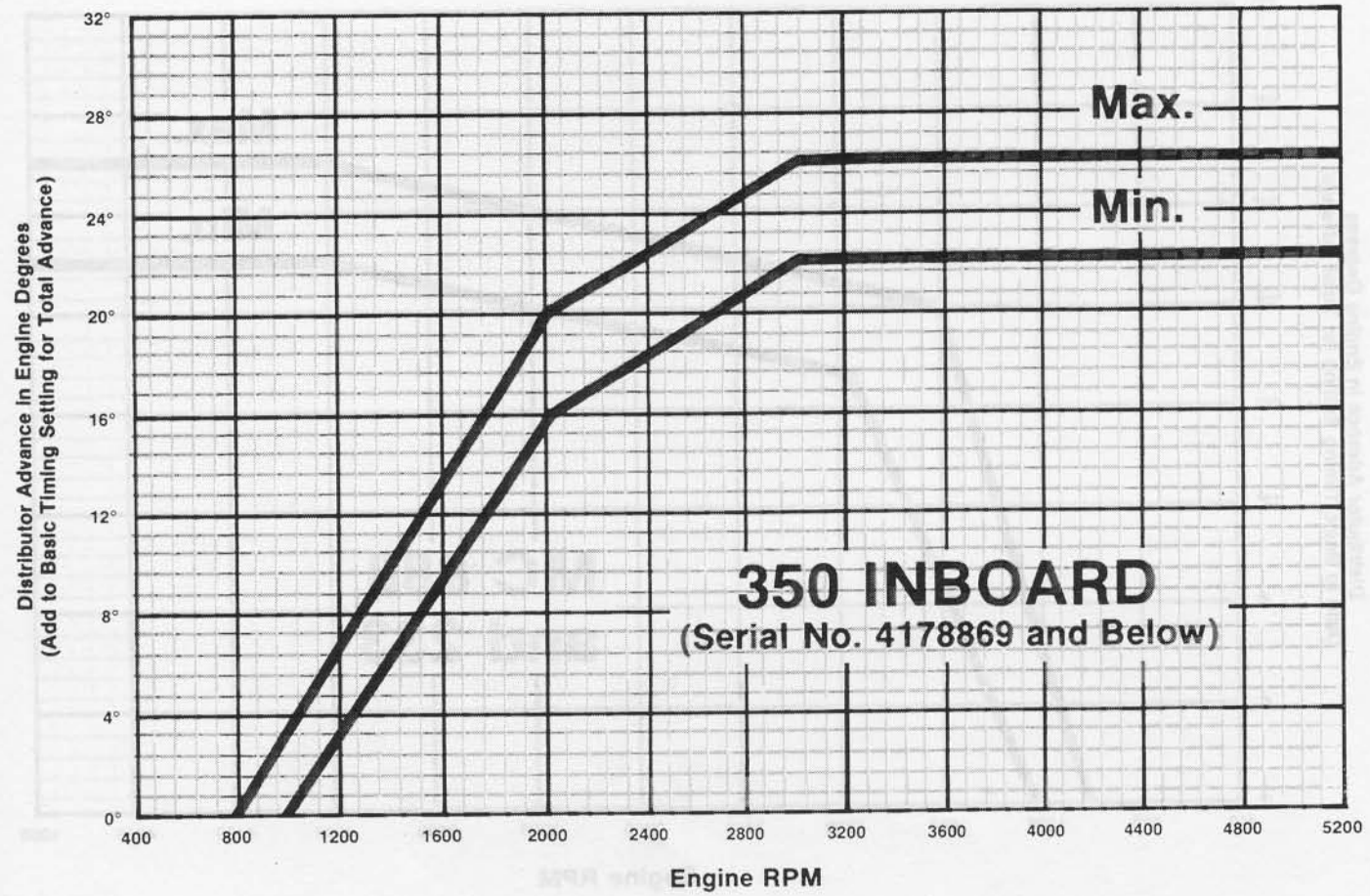
DISTRIBUTOR ADVANCE CURVES





DISTRIBUTOR ADVANCE CURVES





CARBURETOR SPECIFICATIONS

Engine Model	120-140	165	470	888-233	888	225-255	898-198	228	250	255-280	330	350	Jet 400
Carb. Model	2GC	2GC	2GV	2GV	Holley	Holley	2GV	4MV	4MV	4MV	4MV	4MV	4MV
Carb. No.	7043182 7044182 7043184	7043183	7045197 17057132	7044185 7044187 17056197	G317-1 (2 Bore)	6407 6576 (4 Bore)	17057139	17057282 17057283	17057298	7044291 7044290	17057299 17057287	7044286	7044287
Adjustment													
Float Level	5/8" (15.9mm)	5/8" (15.9mm)	11/16" (17.46mm)	19/32" (15.1mm)	Bottom of Sight Plug Hole ± 1/32" (.8mm)		19/32" (15.1mm)	15/64" (5.95mm)	15/64" (5.95mm)	.240" (6.1mm)	15/64" (5.95mm)	.240" (6.1mm)	.240" (6.1mm)
Float Drop	1-7/8" (47.6mm)	1-7/8" (47.6mm)	1-9/32" (32.54mm)	1-9/32" (32.54mm)	—	—	1-9/32" (32.54mm)	—	—	—	—	—	—
Pump Rod	.88" (22.35mm)	.952" (24.2mm)	1-7/32" (30.96mm)	1-3/16" (30.16mm)	.015" to .062" (.38 - 1.57mm)		1-5/32" (29.37mm)	13/32" (10.32mm)	13/32" (10.32mm)	.410" (10.4mm)	13/32" (10.32mm)	.410" (10.4mm)	.410" (10.4mm)
Vacuum Break	—	—	—	—	—	.110" (2.79mm)	—	5/32" (3.97mm)	5/32" (3.97mm)	.155" (3.94mm)	5/32" (3.97mm)	.155" (3.94mm)	.155" (3.94mm)
Air Valve Lockout	—	—	—	—	—	.015" (.38mm)	—	—	—	—	—	.003"-.015" (.08-.38mm)	.003"-.015" (.08-.38mm)
Air Valve Spring Windup	—	—	—	—	—	—	—	7/16 Turn	9/16 Turn	3/8 Turn	5/8 Turn	3/8 Turn	7/16 Turn
Choke Setting	Index Marks				Index Marks			—	See "Note" Below		—	See "Note" Below	
Prelim. Idle Mixture Setting	1-1/4 Turns	1-1/4 Turns	1-1/4 Turns	1-1/4 Turns	1-1/2 Turns	1-1/2 Turns	1-1/4 Turns	1 Turn	1 Turn	1 Turn	1 Turn	1 Turn	1 Turn

NOTE: One Rod Diameter Interference

ALTERNATOR SPECIFICATIONS

Manufacturer's Identification Number	Ground	Rotation	Field Current		Cold Output 5000 RPM	Hot Output
			Amperes	Volts		
1100576	Negative	Same as Engine	4.1-4.5	12	42 Amps	37 Amps
1102393			4.1-4.5	12	43 Amps	39 Amps
398-3631A2			N.A.	N.A.	17 Amps	16 Amps
			Permanent Magnet			
398-3631A4			N.A.	N.A.	43 Amps	41 Amps
			Permanent Magnet			
1102938			3.9-4.7	12	39 Amps	37 Amps
1102939			3.9-4.7	12	39 Amps	37 Amps
8MR2023F			2.9-3.4	12	39 Amps	37 Amps
8MR2024F			2.9-3.4	12	39 Amps	37 Amps

STARTER SPECIFICATIONS

Manufacturer's Identification Number	No Load Test					Brush Spring Tension
	Volts	Min. Amps.	Max. Amps.	Min. RPM	Max. RPM	
1108525 (Delco-Remy)	10.6	45	110	3,500	6,700	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
1108742 (Delco-Remy)	10.6	45	110	3,500	6,700	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
1108755 (Delco-Remy)	10.6	55	110	2,800	6,400	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
1108756 (Delco-Remy)	10.6	55	100	5,200	11,100	40-70 Oz. (1.13-1.98kg) at Head of Brush Screw
MEO 7003 (Prestolite)	Approx. 11	—	85	5,000	—	32-40 Oz. (.91-1.13kg) at Brush Spring Near Brush
MHA 7016 (Prestolite)	11	—	70	5,500	—	32-40 Oz. (.91-1.13kg) at Brush Spring Near Brush

CLOSED COOLING SYSTEM SPECIFICATIONS

Engine Model	Cooling System	Capacity (Qts.)	Cap Pressure (Lbs. Sq. In.)
MCM 120-140-165	B-61086A4	9 (8.5 Liters)	14 (.984kg/cm²)
MCM 470	Standard	10.5 (9.9 Liters)	14 (.984kg/cm²)
MCM 888	B-62472A3	17 (16.1 Liters)	14 (.984kg/cm²)
MCM 898-228-228TR-250 MIE 198-228-255	B-74643A1	20 (18.9 Liters)	14 (.984kg/cm²)
MCM 233	B-72114A1	22 (20.8 Liters)	14 (.984kg/cm²)
MCM 330TR(S)-MIE 330	B-63107A3	22 (20.8 Liters)	14 (.984kg/cm²)

Spark Plug Identification

(MerCruisers and Mercury Outboards)

(Spark Plugs Listed in Numerical Order by MerCruiser Part No.)

MerCruiser Part No.	AC Part No.	Champion Part No.	MerCruiser Stock Status*
C-33-20127		J-6J	Active
C-33-21375		J-8J	NLA
C-33-22265		XJ-6J	NLA
C-33-22805		J-7J	Active
C-33-28915	M44C		C-33-20127
C-33-28916	M45		C-33-22805
C-33-30578		J-4J	Active
C-33-30739		XJ-4J	NLA
C-33-31390	K421		NLA
C-33-31391	M44		NLA
C-33-32443		J-2J	NLA
C-33-33356	46N		C-33-54527
C-33-33743	C42-1		C-33-57953
C-33-34724	43N		NLA
C-33-37083	44F		Active
C-33-37405	C44N		C-33-54527
C-33-38216	C43		C-33-57953
C-33-39440		UL-18V	Active
C-33-39564	UJ-4J		NLA
C-33-39635	L-4J		C-33-53098
C-33-45191		L-19V	C-33-57451
C-33-46028		L-7J	C-33-48370
C-33-46082		L-9J	C-33-48368
C-33-46685	C44XL		Active
C-33-48325	V40N		C-33-57771
C-33-48368	M45FF		Active
C-33-48370	M43FF		Active
C-33-48372	V40		C-33-57769
C-33-53098	M42FF		Active
C-33-54527	CR44N		Active
C-33-54842	WR41N		Active
C-33-54844		RM-J3	C-33-54845
C-33-54845	WR42		Active
C-33-54980	(Autolite BTF-3M)		C-33-61783
C-33-55652	CR43		C-33-57953
C-33-55928	V40FF		C-33-58194
C-33-57451	V40FFM		Active
C-33-57769	V40K		Active
C-33-57771	V40NK		C-33-68546
C-33-57953	CR43K		Active
C-33-57955	42XL		Active
C-33-58194	V40FFK		Active
C-33-58195	R44T		C-33-59571
C-33-58362	SR83T		Active
C-33-59162	S41F		Active
C-33-59571	MR43T		Active
C-33-59599		L-77V	C-33-57451
C-33-59660	MR41T		Active
C-33-59804		D-77V	Active
C-33-60056	CR43N		Active
C-33-60816		RN-3	C-33-70779
C-33-60818	VR40FFM		C-33-68098
C-33-60917		L-78	Active
C-33-60919		L-81	Active
C-33-61783	C83T		Active
C-33-61976	M40FF		Active
C-33-63060		RL-78	Active
C-33-64053		F-10	Active
C-33-65591	QL-77V		C-33-68098
C-33-68057		L-76V	C-33-57451
C-33-68098		QL-76V	Active
C-33-68458		N-55G	Active
C-33-68546		N-19V	Active
C-33-70779	S42XLR		Active
C-33-70781	S43XLR		Active
C-33-72983		QL-7J/ QL-7J5	Not Stocked in U.S.
C-33-73271		QN-19V	Active
C-33-75340		RBL-9Y	Active
C-33-75739		QL-78V	Not Stocked in U.S.
C-33-76154		RBL-11Y	Active

* *If a Part No. is shown in this column, it supersedes the Part No. shown in Col. 1.* *NLA = No Longer Available*

NOTE: Refer to Page 8A-14 for cross-reference of AC or Champion Part Nos. to MerCruiser Part Nos.

HIGH ALTITUDE PERFORMANCE - MERCRUISER ENGINES

High altitude performance tests have shown that very little performance improvement is realized by increased spark advance or carburetor recalibration. On the contrary, reprop-ping the unit to run at its rated RPM has shown a significant increase in performance. Based on this testing, our general recommendation should be to "reprop the unit to its rated RPM in order to obtain maximum performance".

Any recommendation, other than changing props, to obtain rated RPM should be considered a special case and referred to the factory branch or area distributor for specific jet sizes and spark timing settings. These recommendations should not be made until the customer is fully aware of the following points:

1. Operating an engine with the above changes at lower elevation will cause engine failure.
2. Making the above changes (leaner jets and advance spark timing) will result in increased fuel economy, but will not have a significant effect on performance.

Spark Plug Cross-Reference

AC Part Number to MerCruiser Part Number

AC Part No.	MerCruiser Part No.
42XL	C-33-57955
43N	C-33-34724
44F	C-33-37083
46N	C-33-33356
C42-1	C-33-33743
C43	C-33-38216
C44N	C-33-37405
C44XL	C-33-46685
C83T	C-33-61783
CR43	C-33-55652
CR43K	C-33-57953
CR43N	C-33-60056
CR44N	C-33-54527
K421	C-33-31390
M40FF	C-33-61976
M42FF	C-33-53098
M43FF	C-33-48370
M44	C-33-31391
M44C	C-33-28915
M45	C-33-28916
M45FF	C-33-48368
MR41T	C-33-59660
MR43T	C-33-59571
R44T	C-33-58195
S41F	C-33-59162
S42XLR	C-33-70779
S43XLR	C-33-70781
SR83T	C-33-58362
V40	C-33-48372
V40FF	C-33-55928
V40FFM	C-33-57451
V40FFK	C-33-58194
V40K	C-33-57769
V40N	C-33-48325
V40NK	C-33-57771
VR40FFM	C-33-60818
WR41N	C-33-54842
WR42	C-33-54845

Champion Part Number to MerCruiser Part Number

Champion Part No.	MerCruiser Part No.
D-77V	C-33-59804
F-10	C-33-64053
J-2J	C-33-32443
J-4J	C-33-30578
J-6J	C-33-20127
J-7J	C-33-22805
J-8J	C-33-21375
L-4J	C-33-39635
L-7J	C-33-46028
L-9J	C-33-46082
L-19V	C-33-45191
L-76V	C-33-68057
L-77V	C-33-59599
L-78	C-33-60917
L-81	C-33-60919
N-19V	C-33-68546
N-55G	C-33-68458
QL-7J/QL-7J5	C-33-72983
QL-76V	C-33-68098
QL-77V	C-33-65591
QL-78V	C-33-75739
QN-19V	C-33-73271
RBL-9Y	C-33-75340
RBL-11Y	C-33-76154
RL-78	C-33-63060
RM-J3	C-33-54844
RN-3	C-33-60816
UJ-4J	C-33-39564
UL-18V	C-33-39440
XJ-4J	C-33-30739
XJ-6J	C-33-22265

SECTION 8 - SPECIFICATIONS

PART B - INTERNAL ENGINE

A BRUNSWICK COMPANY

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INTERNAL ENGINE SPECIFICATIONS

IN-LINE ENGINES

MODEL	120	140	165	470
DISPLACEMENT CU.IN.	153 (2517cc)	181 (2956cc)	250 (4097cc)	224 (3671cc)
CYLINDER BORE:				
Diameter	3.8745-3.8775 (98.412mm-98.489mm)	3.9995-4.0075 (10.1587-10.1791cm)	3.8745 - 3.8775 (98.412-98.489mm)	4.3602-4.3609 (110.749-110.767mm)
Out of Round — Production	.0005 (.0127mm) Max.			.0005 (.0127mm) Max.
Out of Round — Service	.002 (.0508mm) Max.			.0015 (.0381mm) Max.
Taper — Production — Thrust Side	.0005 (.0127mm) Max.			.0005 (.0127mm) Max.
Taper — Production — Relief Side	.0005 (.0127mm) Max.			.0005 (.0127mm) Max.
Taper — Service	.0005 (.0127mm) Max.			.003 (.076mm) Max.
PISTON: CLEARANCE				
Production	.0005-.0015 (.0127-.0381mm)			.0020-.0037 (.0508-.0939mm)
Service	.0025 (.0635mm) Max.			.0020-.0037 (.0508-.0939mm)
PISTON RING: COMPRESSION				
Groove Clearance — Production — Top	.0012-.0027 (.0305-.0686mm)			.0025-.004 (.0635-.102mm)
Groove Clearance — Production — 2nd	.0012-.0032 (.0305-.0813mm)			.0025-.004 (.0635-.102mm)
Groove Clearance — Service — Top	.0012-.0037 (.0305-.0939mm)			.0025-.004 (.0635-.102mm)
Groove Clearance — Service — 2nd	.0012-.0042 (.0305-.1067mm)			.0025-.004 (.0635-.102mm)
Gap — Production — Top	.010-.020 (.254-.508mm)			.010-.020 (.254-.508mm)
Gap — Production — 2nd	.010-.020 (.254-.508mm)			.010-.020 (.254-.508mm)
Gap — Service — Top	.010-.030 (.254-.762mm)			.010-.020 (.254-.508mm)
Gap — Service — 2nd	.010-.030 (.254-.762mm)			.010-.020 (.254-.508mm)
PISTON RING: OIL				
Groove Clearance — Production	.000-.005 (.127mm)			.0011-.0065 (.0279-.1651mm)
Groove Clearance — Service	.000-.006 (.152mm)			.0011-.0065 (.0279-.1651mm)
Gap — Production	.015-.055 (.381-1.397mm)			.010-.025 (.254-.635mm)
Gap — Service	.015-.065 (.381-1.651mm)			.010-.025 (.254-.635mm)
PISTON PIN:				
Diameter	.9270-.9273 (23.546-23.553mm)			1.0399-1.0402 (26.413-26.421mm)
Clearance — Production	.00015-.00025 (.038-.006mm)			.0004-.0006 (.0102-.0152mm)
Clearance — Service	.001 (.025mm) Max.			.0004-.0006 (.0102-.0152mm)
Fit in Rod	.0008-.0016 (.020-.041mm) Interference			.0006-.0016 (.0152-.0406mm) Interference
CRANKSHAFT:				
Main Journal — Diameter	All 2.2983-2.2993 (5.838-5.840mm)			2.7472-2.7482 (69.779-69.804mm)
Main Journal — Taper — Production	.0002 (.005mm) Max.			.0002 (.0051mm) Max.
Main Journal — Taper — Service	.001 (.025mm) Max.			.0005 (.0127mm) Max.
Main Journal — Out of Round — Production	.0002 (.005mm) Max.			.0002 (.0051mm) Max.
Main Journal — Out of Round — Service	.001 (.025mm) Max.			.0005 (.0127mm) Max.
Main Bearing Clearance — Production	.0003-.0029 (.008-.074mm)			.0009-.0031 (.0228-.0787mm)
Main Bearing Clearance — Service	.004 (.102mm) Max.			.001-.003 (.0254-.0762mm)

(Continued on Next Page)

INTERNAL ENGINE SPECIFICATIONS

IN-LINE ENGINES (Continued)

MODEL			120	140	165	470
Crankshaft End Play			.002-.006 (.051-.152mm) Max.			.006-.010 (.152-.254mm)
Crankpin	Diameter		1.999-2.000 (50.775-50.8mm)	2.099-2.100 (53.315-53.34mm)	1.999-2.000 (50.775-50.8mm)	2.4979-2.4989 (63.447-63.472mm)
	Taper	Production	.0003 (.0076mm) Max.			.0002 (.051mm) Max.
		Service	.001 (.025mm) Max.			.0005 (.0127mm) Max.
	Out of Round	Production	.0002 (.051mm) Max.			.0002 (.0051mm) Max.
		Service	.001 (.025mm) Max.			.0005 (.0127mm) Max.
Rod Bearing Clearance	Production		.0007-.0027(.018-.069mm)	.0007-.0028(.018-.071mm)	.0007-.0027 (.018-.069mm)	.0009-.0031(.0228-.0787mm)
	Service		.004 (.102mm) Max.			.001-.003 (.0254-.0762mm)
Rod Side Clearance			.0085-.0135(.216-.343mm)	.009-.013 (.229-.330mm)	.0085-.0135 (.216-.343mm)	.0050-.0120 (.127mm-.3048mm)
CAMSHAFT:						
End Play						.002-.005 (.0508-.127mm)
Lobe Lift (Max.)		Intake	.2325 (5.906mm)	.2525 (6.414mm)	.2297 (5.834mm)	.278 (7.061mm) Max.
		Exhaust	.2325 (5.906mm)	.2525 (6.414mm)	.2297 (5.834mm)	.290 (7.366mm) Max.
Lobe Wear Limit			—			.009 (.2286mm) Max.
Journal Diameter			1.8682-1.8692 (47.452-47.478mm)			2.1242-2.1248 (53.955-53.970mm)
Bore Diameter			—			2.1258-2.1268 (53.995-54.021mm)
Clearance			—			.0010-.0026 (.0254-.0660mm)
Camshaft Runout			.0015 (.038mm) Max.			.001 (.0254mm) Max.
CYLINDER HEAD						
Gasket Surface Flatness			.003" (.076mm) in Any 6" (15.24cm) or .007" (.178mm) Overall Max.			.005 (.127mm) Max.
VALVE SYSTEM:						
Lifter			Hydraulic			Hydraulic
Rocker Arm Ratio			1.75 to 1			1.73:1
Collapsed Tappet Gap			¾ Turn Down from "O" Lash			.075-.175 (1.905-4.445mm)
Face Angle		Intake	45°			44°
		Exhaust	45°			44°
Seat Angle (Int. & Exh.)			46°			45°
Seat Runout (Int. & Exh.)			.002 (.051mm) Max			.002 (.0051mm) Max.
Seat Width		Intake	1/32-1/16 (.8-1.6mm)		1/32-3/32 (.8-2.4mm)	.060-.080 (1.524-2.032mm)
		Exhaust	1/16-3/32 (1.6-2.4mm)			.060-.080 (1.524-2.032mm)
Stem Clearance	Production	Int.	.0010-.0027 (.025-.069mm)			.0010-.0027 (.0254-.0686mm)
		Exh.	.0015-.0032 (.038-.081mm)			.0010-.0027 (.0254-.0686mm)
	Service	Int.	.0037 (.094mm) Max.			.0037 (.0940mm) Max.
		Exh.	.0052 (.132mm) Max.			.0052 (.1321mm) Max.
Springs	Free Length		2.08 (52.8mm)	—	1.90 (48.3mm)	2.03 (51.562mm) Max.
	Pressure Ft. Lbs.	Closed	78-86 (10.8-11.9mkg) at 1.66 (42.2mm)	83 (11.5mkg) at 1.66 (42.2mm)	54-64 (7.4-8.9mkg) at 1.66 (42.2mm)	76-84 at 1.81 (10.5-11.6mkg at 46.0mm)
		Open	170-180(23.5-24.9mkg) at 1.26 (32mm)	175 (24.2mkg) at 1.26 (32mm)	180-192 (24.9-26.5mkg) at 1.27 (32.3mm)	240-265 at 1.33 (33.2-36.6mkg at 33.8mm)
	Installed Height ±1/32" (.8mm)	Intake	1.6562 (42.07mm)			1.80-1.82 (45.72-46.23mm)
		Exhaust	1.6562 (42.07mm)			1.80-1.82(45.72-46.23mm)
Damper	Free Length		1.94 (49.28mm)	—	—	—
	Approx. No. of Coils		4	—	—	—

INTERNAL ENGINE SPECIFICATIONS - V-8 ENGINES

MODEL			888	225-S	225-TR	233-255TRS - 255TR (Serial No. 4175499 and Below)	350	Jet 400 Series
DISPLACEMENT CU. IN.			302 (4949cc)	302 (4949cc)	302 (4949cc)	351 (5752cc)	454 (7440cc)	454 (7440cc)
CYLINDER BORE:								
Diameter			4.0004-4.0040 (10.161-10.17cm)			4.0004-4.0036 (10.161-10.169cm)	4.2500-4.2520 (10.795-10.8cm)	
Out of Round		Production	.001 (.025mm) Max.					
		Service	.005 (.127mm) Max.				.002 (.051mm)	
Taper	Production	Thrust Side	.0005 (.013mm) Max.					
		Relief Side	.001 (.025mm) Max.					
	Service		.005 (.127mm) Max.					
PISTON: CLEARANCE								
Production			.0018-.0026 (.046-.066mm)				.0040-.0050 (.102-.127mm)	
Service			.0018-.0026 (.046-.066mm)				.006 (.152mm) Max.	
PISTON RING: COMPRESSION								
Groove Clearance	Production	Top	.002-.004 (.051-.102mm)				.0017-.0032 (.043-.081mm)	
		2nd	.002-.004 (.051-.102mm)				.0017-.0032 (.043-.081mm)	
	Service	Top	.002-.004 (.051-.102mm)				.0017-.0042 (.043-.107mm)	
		2nd	.002-.004 (.051-.102mm)				.0017-.0042 (.043-.107mm)	
Gap	Production	Top	.010-.020 (.254-.508mm)					
		2nd	.010-.020 (.254-.508mm)					
	Service	Top	.010-.020 (.254-.508mm)					
		2nd	.010-.020 (.254-.508mm)					
PISTON RING: OIL								
Groove Clearance	Production		"Snug"				.0011-.0075 (.028-.191mm)	
	Service		"Snug"				.0011-.0075 (.028-.191mm)	
Gap	Production		.015-.069 (.381-1.753mm)		.015-.055 (.381-1.397mm)		.010-.025 (.254-.635mm)	
	Service		.015-.069 (.381-1.753mm)		.015-.055 (.381-1.397mm)		.010-.025 (.254-.635mm)	
PISTON PIN:								
Diameter			.9119-.9124 (23.162-23.175mm)				.9895-.9898 (25.133-25.141mm)	
Clearance	Production		.0002-.0004 (.005-.010mm)		.0003-.0005 (.008-.013mm)		.00045-.00055 (.011-.014mm)	
	Service		.0008 (.020mm) Max.				.001 (.025mm) Max.	
Fit in Rod			.0008-.0016 (.020-.041mm) Interference				.0008-.0021 (.020-.053mm)	
CRANKSHAFT:								
Main Journal	Diameter		2.2482-2.2490 (57.104-57.125mm)		2.9994-3.0002 (76.185-76.205mm)	No. 1 2.7475-2.7484 (69.787-69.809mm) No. 2-3-4 2.7481-2.7490 (69.802-69.825mm) No. 5 2.7468-2.7478 (69.769-69.794mm)	No. 1-2-3-4 2.7481-2.7490 (69.802-69.825mm) No. 5 2.7473-2.7483 (69.781-69.807mm)	
	Taper	Production	.0003 (.008mm) Max. per In.				.0002 (.005mm) Max. per In.	
		Service					.001 (.025mm) Max. per In.	
	Out of Round	Production	.0004 (.010mm) Max. per In.				.0002 (.005mm) Max. per In.	
		Service					.001 (.025mm) Max. per In.	

(Continued on Next Page)

INTERNAL ENGINE SPECIFICATIONS - V-8 ENGINES

(Continued)

MODEL			888	225-S	225TR	233-255TRS - 255TR (Serial No. 4175499 and Below)	350	Jet 400 Series
Main Bearing Clearance	Production		No. 1 .0001-.0018 (.003-.046mm) Others .0005-.0024 (.013-.061mm)	No. 5 .0029-.0045 (.074-.114mm)		.0008-.0026 (.020-.066mm)	No. 1 .0019-.0031 (.048-.079mm) No. 2-3-4 .0013-.0025 (.033-.064mm)	No. 1-2-3-4 .0013-.0025 (.033-.064mm) No. 5 .0024-.0040 (.061-.102mm)
	Service		Same as Production					
Crankshaft End Play			.004-.008 (.102-.203mm)				.006-.010 (.152-.254mm)	
Connecting Rod Journal	Diameter		2.1228-2.1236 (53.919-53.939mm)			2.3103-2.3111 (58.682-58.702mm)	2.1985-2.1995 (55.842-55.867mm)	2.2000-2.1990 (55.880-55.855mm)
	Taper	Production	.0004 (.010mm) Max. per In.				.0003 (.008mm) Max. per In.	
		Service					.001 (.025mm) Max. per In.	
	Out of Round	Production	.0004 (.010mm) Max. per In.				.0002 (.005mm) Max. per In.	
		Service					.001 (.025mm) Max. per In.	
Rod Bearing Clearance		Production	.001-.0015 (.025-.038mm)				.0014-.0030 (.036-.076mm)	
		Service	.0008-.0026 (.020-.066mm)				.0035 (.089mm) Max.	
Rod Side Clearance			.010-.020 (.254-.508mm)				.019-.027 (.483-.686mm)	

CAMSHAFT:

Lobe Lift ± .002" (.051mm)	Int.	.260 (6.60mm)	(Models 225TR & 233) .278 (7.06mm)	(Model 255) .267 (6.78mm)	.2714 (6.894mm)	.29412 (7.471mm)
	Exh.	.278 (7.06mm)	.283 (7.19mm)	.273 (6.93mm)	.2824 (7.173mm)	.29412 (7.471mm)
Journal Diameter		No. 1 2.0805-2.0815 (52.845-52.870mm) No. 2 2.0655-2.0665 (52.464-52.489mm) No. 3 2.0505-2.0515 (52.083-52.108mm) No. 4 2.0355-2.0365 (51.702-51.727mm) No. 5 2.0205-2.0215 (51.321-51.346mm)			1.9487-1.9497 (49.497-49.522mm)	
Camshaft Runout		.005 (.127mm) Max.			.0015 (.038mm) Max.	

CYLINDER HEAD:

Gasket Surface Flatness	.003 (.076mm) in Any 6" (15cm) or .007 (.178) Overall Max.

VALVE SYSTEM:

Lifter			Hydraulic				
Rocker Arm Ratio			1.6 to 1				1.70 to 1
Valve Lash (Int. & Exh.)			N.A.				¾ Turn Down from "O" Lash
Face Angle	Intake		44°				45°
	Exhaust		44°				45°
Seat Angle (Int. & Exh.)			45°				46°
Seat Runout (Int. & Exh.)			.0015 (.038mm) Max.				.002 (.051mm) Max.
Seat Width	Intake		1/16-5/64 (1.59-1.98mm)	—	.060 (1.534mm)	.080 (2.032mm)	1/32-1/16 (.79-1.59mm)
	Exhaust			—			1/16-3/32 (1.59-2.38mm)
Stem Clearance	Production	Int.	.0010-.0027 (.025-.069mm)				.0010-.0025 (.025-.064mm)
		Exh.	.0015-.0032 (.038-.081mm)				.0012-.0027 (.030-.069mm)
	Service	Int.	.0010-.0027 (.025-.069mm)				.0010-.0035 (.025-.089mm)
		Exh.	.0015-.0032 (.038-.081mm)				.0012-.0037 (.030-.094mm)
Springs	Free Length		2.07 (52.578mm)				2.10 (53.340mm)
	Pressure Ft. Lbs.	Closed	71-79 (9.8-10.9mkg) at 1.790 (45.466mm)				74-86 (10.2-11.9mkg) at 1.88 (47.752mm)
		Open	190-210 (26.3-29.0mkg) at 1.340 (34.036mm)				288-312 (39.8-43.1mkg) at 1.38 (35.052mm)
	Installed Height ± 1/32" (.8mm)	Intake	1¾-1-13/16 (44.45-46.04mm)				1.88 (47.752mm)
		Exhaust	1¾-1-13/16 (44.45-46.04mm)				1.88 (47.752mm) 1.865 (47.371mm)
Damper	Free Length		—				1.86 (47.244mm)
	Approx. No. of Coils		—				4

INTERNAL ENGINE SPECIFICATIONS - V-8 ENGINES (Continued)

MODEL	898, 228, 228-TR, MIE 198 and MIE 228
DISPLACEMENT CU. IN.	305 (4998cc)

CYLINDER BORE:

Diameter			3.7350-3.7385 (94.869-94.9579mm)
Out of Round		Production	.001 (.0254mm) Max.
		Service	.002 (.0508mm) Max.
Taper	Production	Thrust Side	.0005 (.0127mm) Max.
		Relief Side	.001 (.0254mm) Max.
	Service		.005 (.1270mm) Max.

PISTON: CLEARANCE

Production	.0007-.0017 (.01778-.04318mm)
Service	.0027 (.068580mm) Max.

PISTON RING: COMPRESSION

Groove Clearance	Production	Top	.0012-.0032 (.030480-.081280mm)
		2nd	.0012-.0032 (.030480-.081280mm)
	Service	Top	Hi Limit Production + .001 (.0254mm)
		2nd	Hi Limit Production + .001 (.0254mm)
Gap	Production	Top	.010-.020 (.254-.508mm)
		2nd	.010-.025 (.254-.635mm)
	Service		Hi Limit Production + .01 (.254mm)

PISTON RING: OIL

Groove Clearance	Production	.002-.007 (.0508-.1778mm)
	Service	Hi Limit Production + .001 (.0254mm)
Gap	Production	.015-.055 (.3810-1.397mm)
	Service	Hi Limit Production + .01 (.254mm)

PISTON PIN:

Diameter		.9270-.9273 (23.5458-23.55342mm)
Clearance	Production	.00025-.00035 (.00635-.00889mm)
	Service	.001 (.0254) Max.
Fit in Rod		.0008-.0016 (.02032-.04064mm) Interference

CRANKSHAFT:

Main Journal	Diameter		No. 1 2.4484-2.4493 (62.18936-62.21222mm) No. 2 3 4 2.4481-2.4490 (62.18174-62.2046mm) No. 5 2.4479-2.4488 (62.17666-62.19952mm)
	Taper	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.
	Out of Round	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.

Main Bearing Clearance	Production		No. 1 .0008-.0020 (.02032-.0508mm) No. 2 3 4 .0011-.0023 (.02794-.05842mm) No. 5 .0017-.0032 (.04318-.08128mm)
	Service		No. 1 .002 (.0508mm) Max. All Others .0035 (.0889mm) Max.
Crankshaft End Play			.002-.006 (.0508-.1524mm)
Connecting Rod Journal	Diameter		2.0988 - 2.0998 (53.3095 - 53.3349mm)
	Taper	Production	.0003 (.00762mm) Max.
		Service	.001 (.0254mm) Max.
	Out of Round	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.
Rod Bearing Clearance		Production	.0013-.0035 (.03302-.0889mm)
		Service	.0035 (.0889mm) Max.
Rod Side Clearance			.008-.014 (.2032-.3556mm)

CAMSHAFT:

Lobe Lift ± .002" (.051mm)	Int.	.263 (6.6802mm)
	Exh.	.269 (6.8326mm)
Journal Diameter		1.8682-1.8692 (47.45228-47.47768mm)
Camshaft Runout		.0015 (.0381mm) Max.

CYLINDER HEAD:

Gasket Surface Flatness	.003 (.076mm) in 6 (15.24mm) or .007 (.178mm) Overall-Max.

VALVE SYSTEM:

Lifter			Hydraulic
Rocker Arm Ratio			1.50:1
Valve Lash (Int. & Exh.)			One Turn Down from Zero Lash
Face Angle	Intake		45°
	Exhaust		45°
Seat Angle (Int. & Exh.)			46°
Seat Runout (Int. & Exh.)			.002 (.0508mm) Max.
Seat Width	Intake		1.32 - 1.16 (.79375-1.5875mm)
	Exhaust		1/16 - 3/32 (1.5875-2.38125mm)
Stem Clearance	Production	Int.	.0010-.0027 (.0254-.06858mm)
		Exh.	.0010-.0027 (.0254-.06858mm)
	Service	Int.	.0037 (.09398mm)
		Exh.	.0047 (.11938mm)
Springs	Free Length		2.03 (51.562mm)
	Pressure In. Lbs.	Closed	76-84(87.56-96.78kg-cm)@1.70(43.18mm) Intake. @ 1.61 (40.894mm) Exhaust
		Open	194-206 (222.9074-237.3326kg-cm) @ 1.25 (31.75mm) Intake. @ 1.16 (29.464mm) Exh.
	Installed Height ± 1/32" (.8mm)	Intake	1-23/32 (43.65625mm)
		Exhaust	1-19/32 (40.48125mm)
Damper	Free Length		1.86 (47.244mm)
	Approx. No. of Coils		4

INTERNAL ENGINE SPECIFICATIONS - V-8 ENGINES (Continued)

MODEL			250, 255TR (Serial No. 4175500 and Up), MIE 255 and 280TRS
DISPLACEMENT CU. IN.			350 (5735cc)
CYLINDER BORE:			
Diameter			3.9995-.0025 (10.15873-10.16635mm)
Out of Round		Production	.001 (.0254mm) Max.
		Service	.002 (.0508mm) Max.
Taper	Production	Thrust Side	.0005 (.0127mm) Max.
		Relief Side	.001 (.0254mm) Max.
	Service		.005 (.1270mm) Max.

PISTON: CLEARANCE	
Production	.0007 - .0017 (.01778-.04318mm)
Service	.0027 (.068580mm) Max.

PISTON RING: COMPRESSION			
Groove Clearance	Production	Top	.0012 - .0032 (.030480-.081280mm)
		2nd	.0012 - .0032 (.030480-.081280mm)
	Service	Top	Hi Limit Production + .001 (.0254mm)
		2nd	Hi Limit Production + .001 (.0254mm)
Gap	Production	Top	.010 - .020 (.254-.508mm)
		2nd	.010 - .025 (.254-.635mm)
	Service		Hi Limit Production + .01 (.254mm)

PISTON RING: OIL		
Groove Clearance	Production	.002 - .007 (.0508-.1778mm)
	Service	Hi Limit Production + .001 (.0254mm)
Gap	Production	.015 - .055 (.3810-1.397mm)
	Service	Hi Limit Production + .01 (.254mm)

PISTON PIN:		
Diameter		.9270 - .9273 (23.5458-23.55342mm)
Clearance	Production	.00025 - .00035 (.00635-.00889mm)
	Service	.001 (.0254) Max.
Fit in Rod		.0008 - .0016 (.02032-.04064mm) Interference

CRANKSHAFT:			
Main Journal	Diameter		No. 1 - 2.4484-2.4493 (62.18936-62.21222mm) No. 2 3 4 - 2.4481-2.4490 (62.18174-62.2046mm) No. 5 - 2.4479-2.4488 (62.17666-62.19952mm)
	Taper	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.
	Out of Round	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.

Main Bearing Clearance	Production		No. 1 .0008-.0020 (.02032-.0508mm) No. 2, 3, 4 .0011-.0023 (.02794-.05842mm) No. 5 .0017-.0032 (.04318-.08128mm)
	Service		No. 1 .002 (.0508mm) Max. All Others .0035 (.0889mm) Max.
Crankshaft End Play			.002-.006 (.0508-.1524mm)
Connecting Rod Journal	Diameter		2.0988 - 2.0998 (53.3095 - 53.3349mm)
	Taper	Production	.0003 (.00762mm) Max.
		Service	.001 (.0254mm) Max.
	Out of Round	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.
Rod Bearing Clearance		Production	.0013-.0035 (.03302-.0889mm)
		Service	.0035 (.0889mm) Max.
Rod Side Clearance			.008-.014 (.2032-.3556mm)

CAMSHAFT:		
Lobe Lift ± .002" (.051mm)	Int.	(280) .296" (Others) .263"
	Exh.	(280) .303 (Others) .269
Journal Diameter		1.8682-1.8692 (47.45228-47.47768mm)
Camshaft Runout		.0015 (.0381mm) Max.

CYLINDER HEAD:	
Gasket Surface Flatness	.003 (.076mm) in 6 (15.24mm) or .007 (.178mm) Overall-Max.

VALVE SYSTEM:			
Lifter			Hydraulic
Rocker Arm Ratio			1.50:1
Valve Lash (Int. & Exh.)			One Turn Down from Zero Lash
Face Angle		Intake	45°
		Exhaust	45°
Seat Angle (Int. & Exh.)			46°
Seat Runout (Int. & Exh.)			.002 (.0508mm) Max.
Seat Width		Intake	1/32 - 1/16 (.79375-1.5875mm)
		Exhaust	1/16 - 3/32 (1.5875-2.38125mm)
Stem Clearance	Production	Int.	.0010-.0027 (.0254-.06858mm)
		Exh.	.0010-.0027 (.0254-.06858mm)
	Service	Int.	.0037 (.09398mm)
		Exh.	.0047 (.11938mm)
Springs		Free Length	2.03 (51.562mm)
	Pressure In. Lbs.	Closed	76-84 (87.56-96.78kg-cm)@1.70(43.18mm) Intake @ 1.61 (40.894mm) Exhaust
		Open	194-206 (222.9074-237.3326kg-cm) @ 1.25 (31.75mm)Intake @1.16(29.464mm) Exh.
	Installed Height ± 1/32" (.8mm)	Intake	1-23/32 (43.65625mm)
		Exhaust	1-19/32 (40.48125mm)
Damper	Free Length		1.86 (47.244mm)
	Approx. No. of Coils		4

INTERNAL ENGINE SPECIFICATIONS - V-8 ENGINES (Continued)

MODEL	330-TR, 330-TRS, MIE 330
DISPLACEMENT CU. IN.	454 (7440cc)

CYLINDER BORE:

Diameter			4.2495-4.2525 (10.79373-10.80135mm)
Out of Round		Production	.001 (.0254mm) Max.
		Service	.002 (.0508mm) Max.
Taper	Production	Thrust Side	.0005 (.0127mm) Max.
		Relief Side	.001 (.0254mm) Max.
	Service		.005 (.1270mm) Max.

PISTON: CLEARANCE

Production	.0024 (.06096mm)
Service	.0035 (.0889mm) Max.

PISTON RING: COMPRESSION

Groove Clearance	Production	Top	.0017-.0032 (.04318-.08128mm)
		2nd	.0017-.0032 (.04318-.08128mm)
	Service	Top	Hi Limit Production + .001 (.0254mm)
		2nd	Hi Limit Production + .001 (.0254mm)
Gap	Production	Top	.010-.020 (.254-.508mm)
		2nd	
	Service		Hi Limit Production + .01 (.254mm)

PISTON RING: OIL

Groove Clearance	Production	.0005-.0065 (.0127-.1651mm)
	Service	Hi Limit Production + .001 (.0254mm)
Gap	Production	.015-.055 (.3810-1.397mm)
	Service	Hi Limit Production + .01 (.254mm)

PISTON PIN:

Diameter		.9895-.9898 (25.1333-25.14092mm)
Clearance	Production	.00025-.00035 (.00635-.00889mm)
	Service	.001 (.0254mm) Max.
Fit in Rod		.0008-.0016 (.02032-.04064mm) Interference

CRANKSHAFT:

Main Journal	Diameter		No. 1 2.7485-2.7494 (69.8119-69.83476mm) No. 2, 3, 4 2.7481-2.7490 (69.80174-69.8246mm) No. 5 2.7478-2.7488 (69.7912-69.81952mm)
	Taper	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.
	Out of Round	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.

Main Bearing Clearance	Production	No. 1, 2, 3, 4 .0013-.0025 (.03302-.0635mm) No. 5 .0024-.0040 (.06096-.1016mm)
	Service	No. 1 .002 (.0508mm) Max. All Others .0035 (.0889mm) Max.
Crankshaft End Play		.006-.010 (.1524-.254mm)

Connecting Rod Journal	Diameter		2.1985-2.1995 (55.8419-55.8673mm)
	Taper	Production	.0003 (.00762mm) Max.
		Service	.001 (.0254mm) Max.
	Out of Round	Production	.0002 (.00508mm) Max.
		Service	.001 (.0254mm) Max.
Rod Bearing Clearance		Production	.0009-.0025 (.02286-.0635mm)
		Service	.0035 (.0889mm) Max.
Rod Side Clearance			.013-.023 (.3302-.5842mm)

CAMSHAFT:

Lobe Lift ± .002" (.051mm)	Int.	.271 (6.8834mm)
	Exh.	.282 (7.1628mm)
Journal Diameter		1.9482-1.9492 (49.48428-49.50968mm)
Camshaft Runout		.0015 (.0381mm) Max.

CYLINDER HEAD:

Gasket Surface Flatness	.003 (.076mm) in 6 (15.24mm) or .007 (.178mm) Overall - Max.

VALVE SYSTEM:

Lifter			Hydraulic
Rocker Arm Ratio			1.70:1
Valve Lash (Int. & Exh.)			One Turn Down from Zero Lash
Face Angle		Intake	45°
		Exhaust	45°
Seat Angle (Int. & Exh.)			46°
Seat Runout (Int. & Exh.)			.002 (.0508mm) Max.
Seat Width		Intake	1/32 - 1/16 (.79375-1.5875mm)
		Exhaust	1/16 - 3/32 (1.5875-2.38125mm)
Stem Clearance	Production	Int.	.0010-.0027 (.0254-.06858mm)
		Exh.	.0012-.0029 (.03048-.07366mm)
	Service	Int.	.0037 (.09398mm)
		Exh.	.0049 (.12446mm)
Springs	Free Length		2.12 (53.848mm)
	Pressure In. Lbs.	Closed	74-86 (85.2554kg-cm) @ 1.88 (47.752mm)
		Open	288-312 (331.8048-359.4552kg-cm) @ 1.38 (35.052mm)
	Installed Height ± 1/32" (.8mm)	Intake	1-7/8 (47.625mm)
		Exhaust	
Damper	Free Length		1.86 (47.244mm)
	Approx. No. of Coils		4

SECTION 8 - SPECIFICATIONS

mercruiser

PART C - TORQUE SPECIFICATIONS

MERCURY MARINE

A BRUNSWICK COMPANY

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IN-LINE ENGINE TORQUES

Fastener Location	MerCruiser 120, 140, 165		MerCruiser 470	
	Size	Torque	Size	Torque
Alternator Rotor to Crank	—	—	1/2-20	50 Ft. Lbs. (6.9mkg)
Camshaft Extension Shaft	—	—	5/8-11	□60 Ft. Lbs. (8.3mkg)
Camshaft Thrust Plate	1/4-20	6 (.83mkg)	1/4-20	115 In. Lbs. (129kg-cm)
Camshaft Sprocket Screws	—	—	1/4-20	150 In. Lbs. (173kg-cm)
Carburetor Mounting	5/16-24	12 (1.66mkg)	5/16-24	20 Ft. Lbs. (2.8mkg)
Chain Tightener Bolt	—	—	5/16-18	20 Ft. Lbs. (2.8mkg)
Connecting Rod Cap	11/32-24	33 (4.56mkg)	3/8-24	40 Ft. Lbs. (5.5mkg)
Connecting Rod Cap	3/8-24	40 (5.53mkg)		
Crankshaft Pulley	5/16-24	18 (2.49mkg)	—	—
Coupling to Flywheel	7/16-20	60 (8.30mkg)	7/16-20	60 Ft. Lbs. (8.3mkg)
Cylinder Head	1/2-13	93 (12.86mkg)	9/16-12	130 Ft. Lbs. (18mkg)
Distributor Clamp	3/8-16	20 (2.77mkg)	5/16-18	15 Ft. Lbs. (2.1mkg)
Flywheel Housing to Block	3/8-16	21 (2.90mkg)	3/8-16	30 Ft. Lbs. (4.1mkg)
Front Mount to Block	3/8-16	21 (2.90mkg)	7/16-14	50 Ft. Lbs. (6.9mkg)
Fuel Line	—	—	7/8-20	35 Ft. Lbs. (4.8mkg)
Impeller Cover	—	—	5/16-18	15 Ft. Lbs. (2.1mkg)
Impeller Nut	—	—	1/2-20	□40 Ft. Lbs. (5.5mkg)
Main Bearing Cap	7/16-14	65 (8.99mkg)	1/2-13	55 Ft. Lbs. (7.6mkg)
Manifold to Head (Exhaust)	3/8-24	23 (3.18mkg)	3/8-16	25 Ft. Lbs. (3.5mkg)
Manifold to Head (Intake)			3/8-16	25 Ft. Lbs. (3.5mkg)
Oil Pan (Side)	1/4-20	7 (.97mkg)	5/16-18	130 In. Lbs. (150kg-cm)
Oil Pan (End)	5/16-18	10 (1.38mkg)	5/16-18	130 In. Lbs. (150kg-cm)
Oil Pan Drain Plug	1/2-20	23 (3.18mkg)	3/8 NPS	20 Ft. Lbs. (2.8mkg)
Oil Pump Cover	1/4-20	6 (.83mkg)	1/4-20	120 In. Lbs. (138kg-cm)
Oil Pump to Block	5/16-18	10 (1.38mkg)	3/8-16	25 Ft. Lbs. (3.5mkg)
Oil Pump Pickup	1/4-20	5 (.69mkg)	5/16-18	20 Ft. Lbs. (2.8mkg)
Oil Tube to Block Nuts	—	—	5/16-24	20 Ft. Lbs. (2.8mkg)
Rocker Arm Cover	1/4-20	4 (.55mkg)	1/4-20	90 In. Lbs. (104kg-cm)
Rocker Arm Screw	—	—	5/16-18	△20 Ft. Lbs. (2.8mkg)
Side Cover	—	—	5/16-18	15 Ft. Lbs. (2.1mkg)
Spark Plugs	14mm	15 (2.07mkg)*	14mm	15 Ft. Lbs. (2.1mkg)*
Starter Motor	3/8-16	37 (5.12mkg)	1/2-13	60 Ft. Lbs. (8.3mkg)
Stator to Front Cover	—	—	10-24	45 In. Lbs. (52kg-cm)
Timing Gear Cover	1/4-20	6 (.83mkg)	5/16-18	15 Ft. Lbs. (2.1mkg)
Water Pump Cover	—	—	1/4-20	15 Ft. Lbs. (2.1mkg)
Water Pump to Block	5/16-18	15 (2.07mkg)	—	—

** Torque Spark Plugs with Gaskets to 25 Ft. Lbs. (3.46mkg).*
□ Left Hand Threads
△Torque with Valves Closed

V-8 ENGINE TORQUES

Fastener Location	MerCruiser 888, 225-S, 225-TR		MerCruiser 228, 228-TR, 898 MIE 198, MIE 228		MerCruiser 255-TR & 255-TRS (Serial No. 4175499 and Below), 233, MIE 233		MerCruiser 250, 280-TRS 255-TR & MIE 255 (Serial No. 4175500 and Up)		MerCruiser 330-TR, 330-TRS, 350, MIE 330, Jet 400	
	Size	Torque Ft. Lbs.	Size	Torque Ft. Lbs.	Size	Torque Ft. Lbs.	Size	Torque Ft. Lbs.	Size	Torque Ft. Lbs.
Camshaft Sprocket	3/8-16	43 (5.95mkg)	5/16-18	20 (2.76mkg)	3/8-16	43 (5.95mkg)	5/16-18	20 (2.76mkg)	5/16-18	20 (2.76mkg)
Camshaft Thrust Plate	¼-20	8 (1.11mkg)	—	—	¼-20	8 (1.11mkg)	—	—	5/16-18	20 (2.76mkg)
Crankshaft Damper	5/8-18	80 (11.06mkg)	7/16-20	60 (8.30mkg)	5/8-18	80 (11.06mkg)	7/16-20	60 (8.30mkg)	½-20	85 (11.76mkg)
Carburetor	5/16-24	11 (1.52mkg)	5/16-18	11 (1.52mkg)	5/16-24	11 (1.52mkg)	5/16-18	11 (1.52mkg)	5/16-18	11 (1.52mkg)
Connecting Rod Cap	5/16-24	24 (3.32mkg)	3/8-24	45 (6.22mkg)	3/8-24	40 (5.53mkg)	3/8-24	45 (6.22mkg)	—	—
Connecting Rod Cap	—	—	—	—	—	—	—	—	3/8-24	50 (6.92mkg)
Coupler (See Note 1)	7/16-20	60 (8.30mkg)	7/16-20	60 (8.30mkg)	N.A.	—	7/16-20	60 (8.30mkg)	N.A.	—
Cylinder Head	7/16-14	70 (9.68mkg)	7/16-14	65 (8.99mkg)	½-13	108 (14.94mkg)	7/16-14	65 (8.99mkg)	7/16-14	80 (11.06mkg)
Distributor Hold-Down	5/16-18	15 (2.07mkg)	3/8-16	20 (2.76mkg)	5/16-18	15 (2.07mkg)	3/8-16	20 (2.76mkg)	3/8-16	20 (2.76mkg)
Drive Plate	5/16-18	18 (2.49mkg)	3/8-16	35 (4.84mkg)	5/16-18	18 (2.49mkg)	3/8-16	35 (4.84mkg)	3/8-16	35 (4.84mkg)
Exhaust Manifold	3/8-16	25 (3.46mkg)	3/8-16	20 (2.76mkg)	3/8-16	25 (3.46mkg)	3/8-16	20 (2.76mkg)	3/8-16	20 (2.76mkg)
Flywheel	7/16-20	80 (11.06mkg)	7/16-20	60 (8.30mkg)	7/16-20	80 (11.06mkg)	7/16-20	60 (8.30mkg)	7/16-20	65 (8.99mkg)
Flywheel Housing to Block	7/16-14	40 (5.53mkg)	3/8-16	30 (4.15mkg)	7/16-14	40 (5.53mkg)	3/8-16	20 (2.76mkg)	3/8-16	20 (2.76mkg)
Front Mount	7/16-14	30 (4.15mkg)	3/8-16	30 (4.15mkg)	7/16-14	30 (4.15mkg)	3/8-16	30 (4.15mkg)	3/8-16	35 (4.84mkg)
Fuel Pump	3/8-16	22 (3.04mkg)	3/8-16	30 (4.15mkg)	3/8-16	22 (3.04mkg)	3/8-16	30 (4.15mkg)	3/8-16	20 (2.76mkg)
Intake Manifold	3/8-16	25 (3.46mkg)	3/8-16	30 (4.15mkg)	3/8-16	25 (3.46mkg)	3/8-16	30 (4.15mkg)	3/8-16	30 (4.15mkg)
Main Bearing Cap	7/16-14	65 (8.99mkg)	7/16-14	70 (9.68mkg)	½-13	100 (13.83mkg)	7/16-14	75 (10.37mkg)	½-13	110 (15.21mkg)
Oil Cooler to Housing	5/16-18	11 (1.52mkg)	—	—	N.A.	—	—	—	N.A.	—
Oil Filter Bolt	N.A.	—	—	—	N.A.	—	—	—	N.A.	—
Oil Pan Screw	¼-20	7 (.97mkg)	1/4-20	7 (.97mkg)	¼-20	7 (.97mkg)	¼-20	7 (.97mkg)	5/16-18	11 (1.52mkg)
Oil Pan Screw	5/16-18	10 (1.38mkg)	—	—	5/16-18	10 (1.38mkg)	5/16-18	10 (1.38mkg)	N.A.	—
Oil Drain Plug	½-20	20 (2.76mkg)	1/2-20	20 (2.76mkg)	½-20	15 (2.07mkg)	½-20	20 (2.76mkg)	½-20	20 (2.76mkg)
Oil Pump	3/8-16	25 (3.46mkg)	7/16-14	65 (8.99mkg)	3/8-16	25 (3.46mkg)	7/16-14	65 (8.99mkg)	7/16-14	65 (8.99mkg)
Oil Pump Cover	¼-20	12 (1.66mkg)	1/4-20	6 (.83mkg)	¼-20	12 (1.66mkg)	¼-20	6 (.83mkg)	¼-20	6 (.83mkg)
Oil Pump Pickup Tube	5/16-18	14 (1.94mkg)	—	—	3/8-16	22 (3.04mkg)	—	—	N.A.	—
Rear Mount (See Note 2)	7/16-14	45 (6.22mkg)	7/16-14	45 (6.22mkg)	N.A.	—	7/16-14	45 (6.22mkg)	7/16-14	50 (6.92mkg)
Rocker Arm Cover	¼-20	4 (.55mkg)	1/4-20	4 (.55mkg)	¼-20	4 (.55mkg)	1/4-20	4 (.55mkg)	¼-20	4 (.55mkg)
Spark Plugs	14mm-5/8	15 (2.07mkg)	14mm-5/8	15 (2.07mkg)	18mm	15 (2.07mkg)	14mm	15 (2.07mkg)	14mm	15 (2.07mkg)
Starter Motor	3/8-16	25 (3.46mkg)	7/16-14	50 (6.92mkg)	3/8-16	25 (3.46mkg)	7/16-14	50 (6.92mkg)	7/16-14	50 (6.92mkg)
Thermostat Housing	5/16-18	15 (2.07mkg)	3/8-16	30 (4.15mkg)	5/16-18	15 (2.07mkg)	3/8-16	30 (4.15mkg)	3/8-16	30 (4.15mkg)
Thermostat Housing	5/16-18	15 (2.07mkg)	—	—	5/16-18	15 (2.07mkg)	—	—	N.A.	—
Timing Chain or Gear Cover	5/16-18	13 (1.80mkg)	1/4-20	6 (.83mkg)	5/16-18	13 (1.80mkg)	1/4-20	6 (.83mkg)	¼-20	6 (.83mkg)
Transmission Support Brg.	N.A.	—	—	—	N.A.	—	—	—	N.A.	—
Transmission to Housing	7/16-14	50 (6.92mkg)	7/16-14	50 (6.92mkg)	N.A.	—	7/16-14	50 (6.92mkg)	7/16-14	50 (6.92mkg)
Water Pump	5/16-18	14 (1.94mkg)	3/8-16	30 (4.15mkg)	5/16-18	14 (1.94mkg)	3/8-16	30 (4.15mkg)	3/8-16	30 (4.15mkg)

NOTE 1: "Coupler" Torque Applies to I-Drive Units Only.
NOTE 2: "Rear Mount" Torque Applies to Stern Drive Units Only.

GIMBAL HOUSING TORQUES

Gimbal Housing Location	MerCruiser I		MerCruiser II-TR and II-TRS	
	Thread	Torque Ft. Lbs.	Thread	Torque Ft. Lbs.
Bell Housing to Gimbal Ring, Hinge Pin	5/8-18	60 (2) (8.30mkg)	5/8-18	60 (2) (8.30mkg)
Bell Housing Stud to Drive Shaft Housing, Nut	7/16-20	50 (6) (6.92mkg)	1/2-20	80 (6) (11.06mkg)
Engine Mount Nut, Bolt	1/2-20	35 (2) (4.84mkg)	—	—
Exhaust Bellows Retaining Clamp	—	35-38* (40-44kg-cm)	—	35* (2) (40kg-cm)
Exhaust Cover to Transom Plate, Screw	—	—	5/16-18	12 (2) (1.66mkg)
Exhaust Cover to Transom Plate, Screw	—	—	5/16-24	12 (15) (1.66mkg)
Exhaust Elbow, Screw	3/8-16	20-25 (3) (2.76-3.46mkg)	—	20-25 (6) (2.76-3.46mkg)
Gimbal Housing Stud to Transom Plate, Nut	1/2-13	20-25 (2) (2.76-3.46mkg)	1/2-20	25-30 (8) (3.46-4.15mkg)
Gimbal Housing Stud, Nut	7/16-20	20-25 (2) (2.76-3.46mkg)	—	—
Gimbal Ring to Upper Swivel Shaft, Screw	5/16-18	20 (1) (2.76mkg)	5/16-18	20 (1) (2.76mkg)
Hydraulic Connector to Gimbal Housing Stud, Nut	1/4-28	10 (2) (1.38mkg)	1/4-28	10 (2) (1.38mkg)
Hydraulic Pump Bracket, Screw	5/16-24	14 (3) (1.94mkg)	5/16-18	20 (4) (2.76mkg)
Oil Hose Retaining Clamp	—	—	—	12-15* (4) (11.52-17.28kg-cm)
Reservoir Cover to Transom Plate, Screw	—	—	5/16-18	20 (8) (2.76mkg)
Reverse Lock Valve, Screw	5/16-18	14 (2) (1.94mkg)	—	14 (2) (1.94mkg)
Shift Bellows Clamp	—	35-38* (40-44kg-cm)	—	—
Shift Cable to Core Wire Support, Nut	5/16	15 (1) (2.07mkg)	—	—
Shift Cutout Lever Arm Spring Retainer, Screw	5/16-18	50-75* (1) (57-86kg-cm)	—	—
Steering Lever Coupler Screw, Nut	3/8-24	20 (1) (2.76mkg)	—	—
Steering Lever to Upper Swivel Shaft, Nut	7/16-20	45-50 (6.22-6.92mkg)	7/16-20	45-50 (1) (6.22-6.92mkg)
Steering Link Rod, Castle Nut to Ride-Guide Cable	3/8-24	20* (1) (2.3kg-cm)	3/8-24	20* (1) (23kg-cm)
Steering Link Rod, Castle Nut to Steering Lever	3/8-24	15-18 (1) (2.07-2.49mkg)	3/8-24	15-18 (1) (2.07-2.49mkg)
Transom Plate Carriage Bolt, Nut	1/2-13	20-25 (2) (2.76-3.46mkg)	—	—
Transom Plate to Gimbal Housing, Screw	7/16-14	20-25 (2) (2.76-3.46mkg)	—	—
Universal Joint Bellows Retaining Clamp	—	35-38* (40-44kg-cm)	—	35* (2) (40kg-cm)
Upper Swivel Shaft, Pipe Plug	—	40-45 (5.52-6.21mkg)	—	40-45 (5.52-6.21mkg)
Valve Guide Cover to Bell Housing, Screw	—	—	1/4-28	15 (3) (2.07mkg)

* *In. Lbs.* *(1), (2), (3), Etc. = Quantity*

DRIVE SHAFT HOUSING TORQUES

Drive Shaft Housing Location	MerCruiser I		MerCruiser II-TR and II-TRS	
	Thread	Torque Ft. Lbs.	Thread	Torque Ft. Lbs.
Bell Housing to Drive Shaft Housing Stud, Nut	7/16-20	50 (6) (6.92mkg)	1/2-20	75-85 (6) (10.37-11.76mkg)
Drive Shaft Housing Back (Rear) Cover, Screw	—	—	3/8-16	20 (4) (2.77mkg)
Drive Shaft Housing Top Cover, Screw	3/8-16	20 (4) (2.77mkg)	3/8-16	20 (4) (2.77mkg)
Drive Shaft Housing to Gear Housing Stud, Nut	7/16-20	35 (5) (4.84mkg)	7/16-20	35 (1) (4.84mkg)
Trim Tab Bolt	—	180* (1) (208kg-cm)	7/16-14	180* (1) (208kg-cm)
Universal Joint Cover, Retainer	3-7/8 - 16	200 (1) (27.66mkg)	—	—
Universal Joint Shaft Pinion, Nut	5/8-18	85 (1) (11.76mkg)	1-14	200 (1) (27.66mkg)
Upper Drive Shaft Preload	—	2-6* (2.30-6.91kg-cm)	—	—
Valve Guide to Drive Shaft Housing, Screw	—	—	10-32	30* (3) (34kg-cm)
Water Pocket Cover, Screw	1/4-20	30-40* (4) (35-46kg-cm)	—	—

* *In. Lbs.* *(1), (2), (3), Etc. = Quantity*

GEAR HOUSING TORQUES

Gear Housing Location	MerCruiser I		MerCruiser II-TR		MerCruiser II-TRS	
	Thread	Torque Ft. Lbs.	Thread	Torque Ft. Lbs.	Thread	Torque Ft. Lbs.
Gear Housing to Drive Shaft Housing Screw	3/8-16	28 (1) (3.87mkg)	1/2-13	50 (1) (6.92mkg)	1/2-13	50 (1) (6.92mkg)
Gear Housing to Drive Shaft Housing Stud, Nut	—	—	7/16-20	35 (6) (4.84mkg)	7/16-20	35 (6) (4.84mkg)
Gear Housing Cover, Retainer Spool	4-3/8 - 16	150 (1) (19.75mkg)	5-1/8 - 16	§ (1)	4-3/8 - 16	■(1)
Gear Housing Pinion, Nut	5/8-18	60-80 (1) (8.30-11.06mkg)	3/4-16	150 (1) (20.75mkg)	3/4-16	150 (1) (20.75mkg)
Gear Housing Stud to Drive Shaft Housing, Nut	—	—	7/16-20	35 (1) (4.84mkg)	7/16-20	35 (1) (4.84mkg)
Propeller Shaft, Nut	3/4-16	40 ± 5 (1) (46±6kg-cm)	1-14	40±5 (1) (46±6kg-cm)	3/4-16	40±5 (1) (46±6kg-cm)
Trim Tab to Gear Housing, Screw	7/16-14	180* (1) (208kg-cm)	7/16-14	180* (1) (208kg-cm)	7/16-14	180* (1) (208kg-cm)
Water Pump Housing Screw (Plastic)	1/4-20	15-20* (1) (17-23kg-cm)	—	—	—	—
Water Pump Housing Stud, Nut (Plastic)	1/4-28	25-30* (2) (29-35kg-cm)	—	—	—	—
Water Pump Housing Stud, Nut (Plastic)	5/16-24	35-40* (1) (40-46kg-cm)	—	—	—	—

* *In. Lbs.* *(1), (2), (3), Etc. = Quantity*

■ *Tighten Cover until Specified Propeller Shaft Bearing Preload Is Obtained.*

§ *Serial No. 3786859 and Below - 200 Ft. Lbs. (27.66mkg)*

§§ *Serial No. 3786860 and Above - Tighten Cover until Specified Propeller Shaft Bearing Preload Is Obtained.*

BEARING PRELOAD TORQUES - MERCRUISER II-TR

NOTE: Chart Is Set Up for NEW Bearings Only. For Old Bearings, Use Approximately 50% of These Values.

Bearing Preload Torque	Specifications
Upper Drive Shaft Only (Located in Drive Shaft Housing)	5-15 In. Lbs. (6-17kg-cm)
Drive Shaft Housing Complete (Upper Drive Shaft and Universal Joint Shaft Recorded at Upper Drive Shaft)	Upper Drive Shaft Torque Plus 5-11 In. Lbs. (6-13kg-cm)
Propeller Shaft	Right Hand Rotation: 8-15 In. Lbs. (9-17kg-cm) Left Hand Rotation: 8-15 In. Lbs. (9-17kg-cm)
Drive Unit Overall Preload (Recorded from Propeller Shaft); Refer to "Explanation of Preload Chart", Following.	1.5 Multiplied by Drive Shaft Housing Complete Preload Torque, Plus Propeller Shaft Bearing Preload Torque, Plus 5-15 In. Lbs. (6-17kg-cm)

Explanation of Preload Chart - MerCruiser II-TR

Before lower drive shaft (located in gear housing) bearing preload torque is measured, determine how much combined bearing preload has already been applied to drive unit bearings. The drive shaft housing complete bearing preload is measured from upper drive shaft, as illustrated in "Drive Shaft Housing Reassembly" in Section 6.

Let's say that drive shaft housing over-all bearing preload is set at 18 in. lbs. (21kg-cm). Because preload readings now will be measured through gear housing from propeller shaft, and gear housing has a 1.5 to 1 gear ratio, drive shaft housing over-all bearing preload must be multiplied by 1.5 (example, Step 1, following). Preload reading then is 27 in. lbs. (31kg-cm), as measured from propeller shaft. If a fraction exists in the answer, drop the fraction. Add the propeller shaft bearing preload, determined in "Gear Housing Reassembly", Section 6, to drive shaft housing complete preload, measured from propeller shaft.

If propeller shaft preload is 12 in. lbs. (14kg-cm), total will be 39 in. lbs. (45kg-cm) (example, Step 2, following). This is the bearing preload torque on drive unit, measured from propeller shaft before gear housing to drive shaft housing nuts are tightened, which applies a preload to the lower drive shaft tapered roller bearings. Drive unit over-all preload torque is 5-15 in. lbs. (6-17kg-cm) above this value (example, Step 3, following, and chart example shaded area, following, 44-54 in. lbs. [51-62kg-cm]). To obtain over-all preload torque, refer to "Gear Housing Installation" Section 6.

EXAMPLE, STEP 1

18 In. Lb. (21kg-cm) Drive Shaft Housing Complete Preload Torque, Measured from Upper Drive Shaft
x1.5 Gear Housing Gear Ratio
27 In. Lb. (31kg-cm) Drive Shaft Housing Complete Preload Torque, Measured from Propeller Shaft

EXAMPLE, STEP 2

27 In. Lb. (31kg-cm) Drive Shaft Housing Complete Preload Torque, Measured from Propeller Shaft
+12 In. Lb. (14kg-cm) Propeller Shaft Bearing Preload Torque
39 In. Lb. (45kg-cm) Drive Unit Preload Less Lower Drive Shaft Bearings

EXAMPLE, STEP 3

39 — 39 In. Lb. (45kg-cm) Drive Unit Preload Less Lower Drive Shaft Bearings
+5 (6kg-cm) — +15 In. Lb. (17kg-cm) (Minimum and Maximum) Lower Drive Shaft Preload Only
44 (51kg-cm) — 54 In. Lb. (62kg-cm) (Minimum and Maximum) Over-all Drive Unit Preload at Propeller Shaft

Bearing Preload Chart - MerCruiser II-TR Drive Unit

DRIVE SHAFT HOUSING (COMPLETE) TORQUES (In. Lbs.)

PROPELLER SHAFT TORQUES (In. Lbs.)	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
8	28 to 38	29 to 39	31 to 41	32 to 42	34 to 44	35 to 45	37 to 47	38 to 48	40 to 50	41 to 51	43 to 53	44 to 54	46 to 56	47 to 57	49 to 59	50 to 60	52 to 62
9	29 to 39	30 to 40	32 to 42	33 to 43	35 to 45	36 to 46	38 to 48	39 to 49	41 to 51	42 to 52	44 to 54	45 to 55	47 to 57	48 to 58	50 to 60	51 to 61	53 to 63
10	30 to 40	31 to 41	33 to 43	34 to 44	36 to 46	37 to 47	39 to 49	40 to 50	42 to 52	43 to 53	45 to 55	46 to 56	48 to 58	49 to 59	51 to 61	52 to 62	54 to 64
11	31 to 41	32 to 42	34 to 44	35 to 45	37 to 47	38 to 48	40 to 50	41 to 51	43 to 53	44 to 54	46 to 56	47 to 57	49 to 59	50 to 60	52 to 62	53 to 63	55 to 65
12	32 to 42	33 to 43	35 to 45	36 to 46	38 to 48	39 to 49	41 to 51	42 to 52	44 to 54	45 to 55	47 to 57	48 to 58	50 to 60	51 to 61	53 to 63	54 to 64	56 to 66
13	33 to 43	34 to 44	36 to 46	37 to 47	39 to 49	40 to 50	42 to 52	43 to 53	45 to 55	46 to 56	48 to 58	49 to 59	51 to 61	52 to 62	54 to 64	55 to 65	57 to 67
14	34 to 44	35 to 45	37 to 47	38 to 48	40 to 50	41 to 51	43 to 53	44 to 54	46 to 56	47 to 57	49 to 59	50 to 60	52 to 62	53 to 63	55 to 65	56 to 66	58 to 68
15	35 to 45	36 to 46	38 to 48	39 to 49	41 to 51	42 to 52	44 to 54	45 to 55	47 to 57	48 to 58	50 to 60	51 to 61	53 to 63	54 to 64	56 to 66	57 to 67	59 to 69

METRIC CONVERSION CHART (In. Lbs. to Metric Kg-Cm)

In. Lbs.	Kg-Cm	In. Lbs.	Kg-Cm	In. Lbs.	Kg-Cm	In. Lbs.	Kg-Cm	In. Lbs.	Kg-Cm	In. Lbs.	Kg-Cm	In. Lbs.	Kg-Cm
5	5.8	20	23.0	35	40.3	50	57.6	65	74.9	80	92.2	95	109.4
6	6.9	21	24.2	36	41.5	51	58.8	66	76.0	81	93.3	96	110.6
7	8.1	22	25.3	37	42.6	52	60.0	67	77.2	82	94.5	97	111.7
8	9.2	23	26.5	38	43.8	53	61.1	68	78.3	83	95.6	98	112.9
9	10.4	24	27.6	39	44.9	54	62.2	69	79.5	84	96.8	99	114.0
10	11.5	25	28.8	40	46.1	55	63.4	70	80.6	85	97.9	100	115.2
11	12.7	26	30.0	41	47.2	56	64.5	71	81.8	86	99.1	101	116.4
12	13.8	27	31.1	42	48.4	57	65.7	72	82.9	87	100.2	102	117.5
13	15.0	28	32.3	43	49.5	58	66.8	73	84.1	88	101.4	103	118.7
14	16.1	29	33.4	44	50.7	59	68.0	74	85.2	89	102.5	104	119.8
15	17.3	30	34.6	45	51.8	60	69.1	75	86.4	90	103.7	105	121.0
16	18.4	31	35.7	46	53.0	61	70.3	76	87.6	91	104.8	106	122.1
17	19.6	32	36.9	47	54.1	62	71.4	77	88.7	92	106.0	107	123.3
18	20.7	33	38.0	48	55.3	63	72.6	78	89.9	93	107.1	108	124.4
19	21.9	34	39.2	49	56.4	64	73.7	79	91.0	94	108.3	109	125.6
												110	126.7

BEARING PRELOAD TORQUES - MERCRUISER 255 II-TRS

Chart Is Set Up for NEW Bearings Only. For Old Bearings, Use Approximately 40% of These Values.

Bearing Preload Torque	Specifications
Upper Drive Shaft Only (Located in Drive Shaft Housing)	5-15 In. Lbs. (6-17kg-cm)
Drive Shaft Housing Complete (Upper Drive Shaft and Universal Joint Shaft Recorded at Upper Drive Shaft)	Upper Drive Shaft Torque Plus 5-11 In. Lbs. (6-13kg-cm)
Propeller Shaft	Right Hand Rotation: 8-15 In. Lbs. (9-17kg-cm) Left Hand Rotation: 8-15 In. Lbs. (9-17kg-cm)
Drive Unit Overall Preload (Recorded from Propeller Shaft), Refer to "Explanation of Preload Chart", Following.	Drive Shaft Housing Complete Preload Torque, Plus Propeller Shaft Bearing Preload Torque, Plus 2-6 In. Lbs. (2-7kg-cm).

Explanation of Preload Chart - MerCruiser 255 II-TRS

When 255-TRS drive unit is assembled, bearing preload is set for each shaft as assembled per Section 6. However, since the lower drive shaft receives its preload from shim pack in drive shaft housing, it cannot be checked like other shafts. It is important that the lower drive shaft is preloaded correctly, since too much preload will result in failure of the small bearing, and too little will allow gearcase pinion to move up out of mesh, thus increasing gear noise and shortening gear life.

Drive shaft housing preload (as used in determining complete drive unit preload) is the measured preload of complete drive shaft housing (assembled per Section 6).

NOTE: Drive shaft housing complete preload torque is NOT multiplied by gear housing gear ratio (as in MerCruiser II-TR), because gear housing has a 1:1 gear ratio.

The gear housing (assembled per Section 6) complete preload consists only of propeller shaft preload, since lower drive shaft bearings are unloaded when not shimmed into the drive shaft housing.

To determine if lower drive shaft has received the correct preload, complete drive unit measured preload (taken at the prop shaft) is compared to sum of the prop shaft and drive shaft housing preload. Total drive unit preload, as measured, should be 2 to 6 in. lbs. (2.3 to 6.9kg-cm) greater than above calculated sum.

A table of required complete drive unit preload (following) is provided in order to eliminate above calculations. Correct range for complete drive unit preload can be found, if measured values for drive shaft housing and propeller shaft are known. If unit's preload, as measured, is not within that range, try turning propeller shaft several times to allow bearings to seat, then recheck.

NOTE: Bearings should have some oil on surface and not be dry.

If measured preload for complete unit then does not agree with chart value, housings must be split and rechecked.

Bearing Preload Chart - MerCruiser 255 II-TRS Drive Unit

DRIVE SHAFT HOUSING (COMPLETE) TORQUES (In. Lbs.)

PROPELLER SHAFT TORQUES (In. Lbs.)

	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
8	20 to 24	21 to 25	22 to 26	23 to 27	24 to 28	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40
9	21 to 25	22 to 26	23 to 27	24 to 28	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41
10	22 to 26	23 to 27	24 to 28	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42
11	23 to 27	24 to 28	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43
12	24 to 28	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43	40 to 44
13	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43	40 to 44	41 to 45
14	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43	40 to 44	41 to 45	42 to 46
15	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43	40 to 44	41 to 45	42 to 46	43 to 47

(For Metric Conversion, See Chart on P. 8C-7)

BEARING PRELOAD TORQUES
MERCRUISER 280-TRS and 330-TRS

Chart Is Set Up for NEW Bearings Only. For Used Bearing, Use Approximately 40% of These Values.

Bearing Preload Torque	Specifications
Upper Drive Shaft Only (Located in Drive Shaft Housing)	5-15 In. Lbs. (6-17kg-cm)
Drive Shaft Housing Complete (Upper Drive Shaft and Universal Joint Shaft Recorded at Upper Drive Shaft)	Upper Drive Shaft Torque, Plus 5-11 In. Lbs. (6-13kg-cm)
Propeller Shaft - Taken at Propeller Shaft	Right Hand and Left Hand Rotation: 8-15 In. Lbs. (9-17kg-cm)
Drive Unit Overall Preload (Recorded from Propeller Shaft; Refer to "Explanation of Preload", Following)	1.125 Multiplied by Drive Shaft Housing Complete Preload Torque, Plus Propeller Shaft Bearing Preload Torque, Plus 2-6 In. Lbs. (2-7kg-cm)

PRELOAD MEASUREMENT TECHNIQUE

1. Apply a few drops of Quicksilver Super-Duty Oil to all bearings and gears that will be involved. A dry bearing will give very erratic results.
2. Turn the shaft several revolutions in the same direction to allow the bearings to seat.
3. With an inch-pound torque wrench, slowly turn the shaft in the same direction and observe the reading while maintaining a smooth turning motion.

Explanation of Preload
MerCruiser 280-TRS and 330-TRS

When the TRS drive unit is assembled, bearing preload is set for each shaft as assembled per Section 6. However, since the lower drive shaft receives its preload from shim pack in drive shaft housing, it cannot be checked like other shafts. It is important that the lower drive shaft is preloaded correctly, since too much preload will result in failure of the small bearing, and too little will allow gearcase pinion to move up out of mesh, thus increasing gear noise and shortening gear life.

Drive shaft housing preload (as used in determining complete drive unit preload) is the measured preload of complete drive shaft housing (assembled per Section 6) multiplied by gear ratio in gear housing (1.125).

The gear housing (assembled per Section 6) complete preload consists only of propeller shaft preload, since lower drive shaft bearings are unloaded when not shimmed into the drive shaft housing.

To determine if lower drive shaft has received the correct preload, complete drive unit measured preload (taken at the prop shaft) is compared to sum of the prop shaft and drive shaft housing preload. Drive shaft housing preload first is multiplied by gear ratio in gear housing. Total drive unit preload, as measured, should be 2 to 6 in. lbs. (2.3 to 6.9kg-cm) greater than above calculated sum.

A table of required complete drive unit preload (following) is provided in order to eliminate above calculations. Correct range for complete drive unit preload can be found, if measured values for drive shaft housing and propeller shaft are known. If unit's preload, as measured, is not within that range, try turning propeller shaft several times to allow bearings to seat, then recheck.

NOTE: Bearings should have some oil on surface and not be dry.

If measured preload for complete unit then does not agree with chart value, housings must be split and rechecked.

EXAMPLE: MC 280-330-TRS Bearing Preload

Assume that slotted nut on upper drive shaft was tightened until shaft bearing preload measured 12 in. lbs. (14kg-cm).

The universal joint shaft then is positioned in drive shaft housing according to reassembly instructions in Section 6. Preload is set by shims under back cover and is adjusted until entire drive shaft housing over-all preload, measured at splined coupling on drive shaft, is 5 to 11 in. lbs. (6 to 13kg-cm) more than upper drive shaft preload torque. Since upper drive shaft was set up so that it measured 12 in. lbs., then total drive shaft housing should be within 17 to 23 in. lbs. (20 to 26 kg-cm). Assume, for this example, that measured over-all drive shaft housing preload is 20 in. lbs. (23kg-cm).

The gear housing is assembled following the procedures in Section 6. Propeller shaft preload is measured and found to be 14 in. lbs. (16kg-cm).

Using chart (following) for over-all drive preload, correct over-all drive preload will be 39 to 43 in. lbs. (45 to 52kg-cm). This is illustrated by the shaded area in the preload chart.

The two housings now are mated together, following "gear housing installation" procedure of Section 6. After excess shims have been removed and housings bolted together, measure over-all preload. If over-all preload (as measured) is above chart limit of 43 in. lbs., then either lower drive shaft bearing has too many shims or bearings have not yet seated. Turn the propeller shaft several times in same direction and recheck. If still not within specifications, housings must be split and rechecked.

Bearing Preload Chart - MerCruiser 280-TRS and 330-TRS

DRIVE SHAFT HOUSING (COMPLETE) TORQUES (In. Lbs.)

PROPELLER SHAFT TORQUES (In. Lbs.)

	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
8	21 to 25	22 to 26	24 to 28	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43
9	22 to 26	23 to 27	25 to 29	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43	40 to 44
10	23 to 27	24 to 28	26 to 30	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	35 to 39	36 to 40	37 to 41	38 to 42	39 to 43	40 to 44	41 to 45
11	24 to 28	25 to 29	27 to 31	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	36 to 40	37 to 41	38 to 42	39 to 43	40 to 44	41 to 45	42 to 46
12	25 to 29	26 to 30	28 to 32	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	37 to 41	38 to 42	39 to 43	40 to 44	41 to 45	42 to 46	43 to 47
13	26 to 30	27 to 31	29 to 33	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	38 to 42	39 to 43	40 to 44	41 to 45	42 to 46	43 to 47	44 to 48
14	27 to 31	28 to 32	30 to 34	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	39 to 43	40 to 44	41 to 45	42 to 46	43 to 47	44 to 48	45 to 49
15	28 to 32	29 to 33	31 to 35	32 to 36	33 to 37	34 to 38	35 to 39	36 to 40	37 to 41	38 to 42	40 to 44	41 to 45	42 to 46	43 to 47	44 to 48	45 to 49	46 to 50

(For Metric Conversion, See Chart on P. 8C-7)

TRANSMISSION TORQUE - DIRECT DRIVE

Fastener Location	Size	Torque Ft./Lbs.
Pump to Adaptor	5/16-18 x 1½	17-22 (2.35-3.04mkg)
Adaptor to Case	3/8-16 x 1¼	27-37 (3.73-5.12mkg)
Valve Cover to Case	¼-20 x 5/8	8-11 (1.11-1.52mkg)
Shift Lever to Valve	5/16-24	8-11 (1.11-1.52mkg)
Bearing Retainer to Case	7/16-14 x 1¼	42-50 (5.81-6.92mkg)
Output Shaft Nut	1-20	100-200 (13.83-27.66mkg)
Cooler Return to Case	¾-14	25-35 (3.46-4.84mkg)
Case Pipe Plug	1/8-27	7-12 (.97-1.66mkg)
Adaptor Pipe Plug	¼-18	12-20 (1.66-2.77mkg)
Case Pipe Plug	3/8-18	17-27 (2.35-3.73mkg)
Dipstick Assembly	¾-14	10-15 (1.38-2.07mkg)

TRANSMISSION TORQUE - MERCRUISER II-TR & TRS

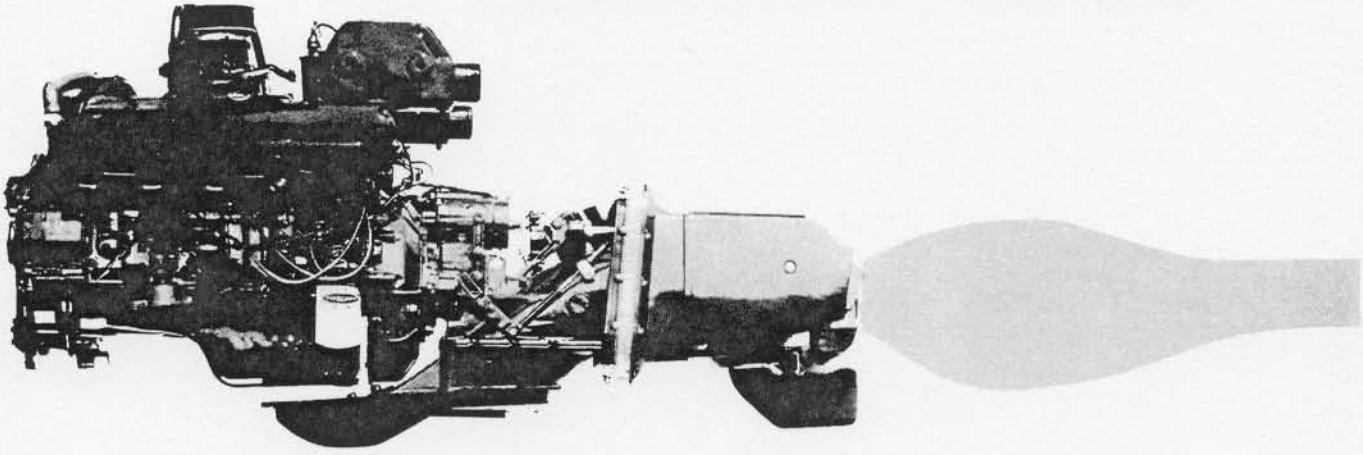
Fastener Location	Size	Torque (In./Lbs.)
Shift Arm to Control Shaft	¼-28	75 (86kg-cm)
Control Valve Cap to Housing	¼-28	70-80 (81-92kg-cm)
Reverse Lock Valve Cam Follower to Control Valve Cap	10-32	30 (35kg-cm)
Allen Plug in Output Shaft	1/8	90 (104kg-cm)
Oil Discharge Passage Plug	5/8	300 (346kg-cm)
Relief Passage Plug	5/8	300 (346kg-cm)
Allen Plug In Pump Housing	¼	192 (221kg-cm)
Oil Pickup Tube Allen Screw	¼-28	90 (104kg-cm)
Cooler Tube to Cooler Cover	½-20	125 (144kg-cm)
Plug on Cooler Cover	3/8	252 (290kg-cm)
Oil Cooler to Transmission	¼-28	85-95 (98-109kg-cm)
Breather Vent		90 (104kg-cm)
Output Housing to Transmission	5/16-18	204-228 (235-263kg-cm)
Grease Fitting to Output Bearing Retainer		20 (23kg-cm)
Control Valve to Transmission	5/16-18	204-228 (235-263kg-cm)
Pump Housing to Transmission	5/16-18	125-135 (144-156kg-cm)
Pump Cover to Pump Housing	¼-28	85-95 (98-109kg-cm)
Reverse Band		120 (138kg-cm) and Back Off 1¾ Turns
Actuating Motor to Bracket		90 (104kg-cm)
Motor Bracket to Control Valve Housing	5/16-18	125-135 (144-156kg-cm)
Reverse Lock Valve to Motor Bracket	¼-28	70 (81kg-cm)
Output Bearing Retainer to Output Housing	¼-28	70 (81kg-cm)

SECTION 8 - SPECIFICATIONS

PART D - PROPELLER CHART

A BRUNSWICK COMPANY

JET 400 DRIVE



Section 9

JET 400 DRIVE

Section 9

IMPORTANT SAFETY NOTIFICATION

Correct service and repair is important for the safe, efficient operation of all mechanical products. The service procedures, that are recommended and described in this service manual, are effective methods for performing service operations.

Some repair procedures require special tools which should be used where specified and as recommended. Pay special attention to the "Warnings" and/or "Cautions" (printed in bold type in this manual), which relate to a specific service procedure that can damage the product, render it unsafe or cause personal injury. Remember, however, that these "Warnings" and/or "Cautions" are not all-inclusive.

We could not possibly know of and advise the service trade of all conceivable procedures in which a service might be performed and of the possible hazards and/or results of each method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a service procedure and/or tool, which is not recommended by Mercury Marine, first must completely satisfy himself that neither his nor the product's safety will be endangered by the service procedure selected.

JET DRIVE and ENGINE REMOVAL

ENGINE

REMOVAL

1. Disconnect positive (+) and negative (-) battery cables from battery.
2. Disconnect the following from jet engine:
   a. Exhaust hoses
   b. Water pickup hose
   c. Fuel line
   d. Throttle cable
   e. Instrument harness
   f. Ground wire from trim actuator
   g. Neutral safety switch wire from solenoid
3. Remove 6 engine bell housing to drive unit engine mount nuts and washers.
4. Remove engine mount to stringers lag screws. Lift engine slightly until engine can be moved forward to disengage drive shaft splines. Remove engine from boat.

DRIVE UNIT

REMOVAL

1. Remove the following from jet drive:

   NOTE: Refer to component removal. (Use "Index".)

   a. Shift cable
   b. Shift bracket assembly
   c. Ride-Guide steering cable
   d. Trim actuator assembly
   e. Stator housing cover
2. Remove 8 nuts, lockwashers and transom seal retainer backup plates. Remove 2 lag bolts and remove seal retainer with sealing ring.

CAUTION: Support drive unit outside of boat when removing bolts in the following step.

3. Remove 14 drive shaft housing to inlet housing bolts and lockwashers.
4. Remove drive unit thru transom.

INLET HOUSING

REMOVAL

CAUTION: DO NOT remove inlet housing, unless replacement is necessary.

1. Remove 18 screws and lockwashers.
2. Break inlet housing loose from epoxy with a large mallet or chisel epoxy loose. Be careful not to chisel into boat bottom. Grind all old epoxy from boat.

JET DRIVE and ENGINE INSTALLATION
WATER INTAKE HOUSING

REASSEMBLY

Position grate assembly in intake housing (Figure 1) and install 4 flat head retaining screws. Torque screws to specifications.

INSTALLATION

1. Remove all old epoxy from boat surface (inside and outside) by grinding or sanding.
2. Follow installation instructions which accompany new water intake housing.

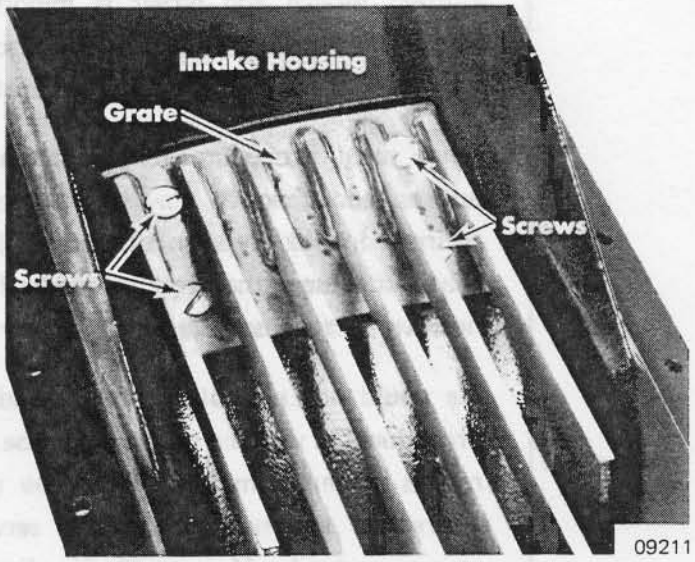


Figure 1. Installing Intake Housing Grate

DRIVE SHAFT HOUSING

INSTALLATION

1. Remove stator housing cover by loosening 2 attaching bolts in cover and lifting cover.
2. Remove shift bracket assembly by removing 2 bolts and washers. (Figure 2) Tilt bracket assembly approximately 45°, then pull bracket assembly forward off shift shaft. Also remove trim actuator assembly (if installed).

CAUTION: Matching surfaces on the drive shaft housing and inlet housing must be free of nicks and dents that may cause water or air leaks.

3. Be sure that the machined surface of water inlet housing is clean, then install gasket.

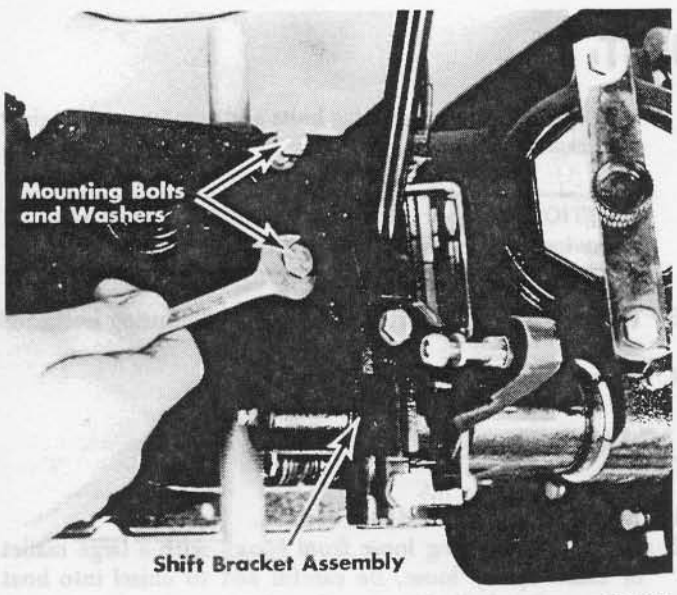


Figure 2. Removing Shift Bracket Assembly

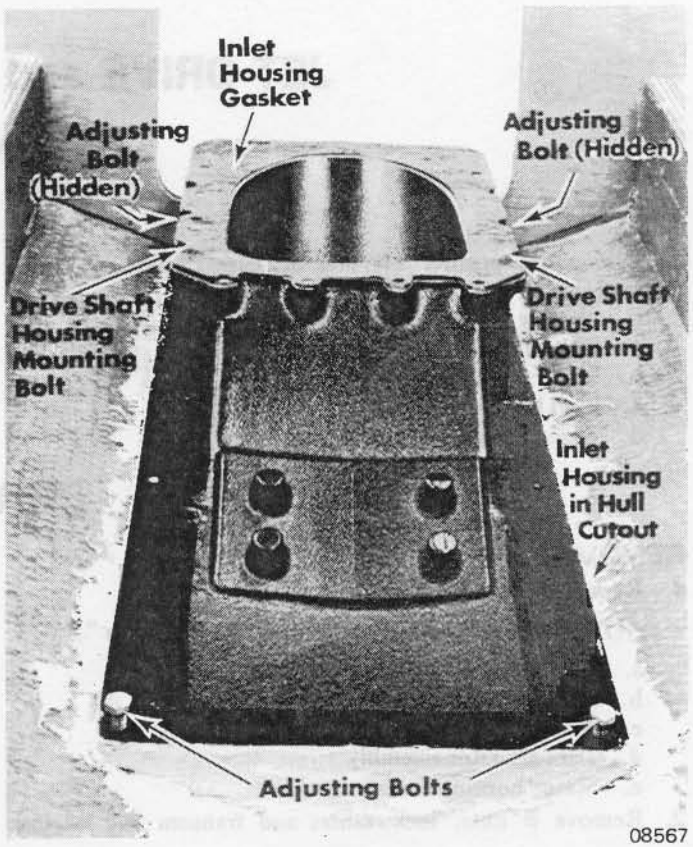


Figure 3. Inlet Housing Gasket Position

4. Install 2 drive shaft housing mounting bolts as guides into inlet housing (to hold gasket in place). (Figure 3)
5. Install drive shaft housing assembly through transom cutout and secure drive shaft housing to inlet housing with 14 bolts (coated with Perfect Seal [C-92-34227]) and lockwashers. Torque bolts evenly to specifications. (Figure 4)

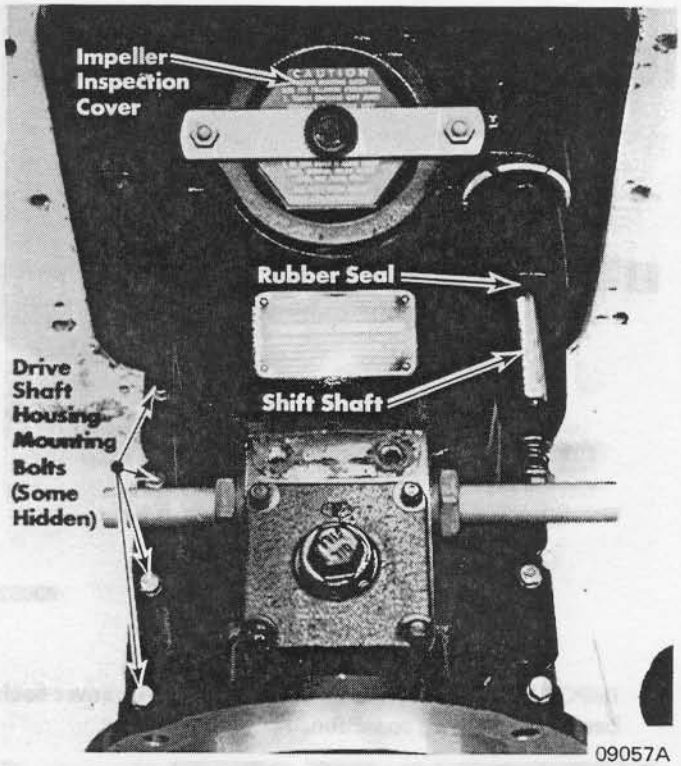


Figure 4. Installing Drive Shaft Housing Assembly

CAUTION: Care must be exercised to prevent damage to sealing ring while installing ring over rudder stator assembly and impeller housing.

6. Apply a heavy coat of liquid soap to transom sealing ring and impeller housing. (Figure 5) Install transom seal retainer assembly as shown in Figure 5.

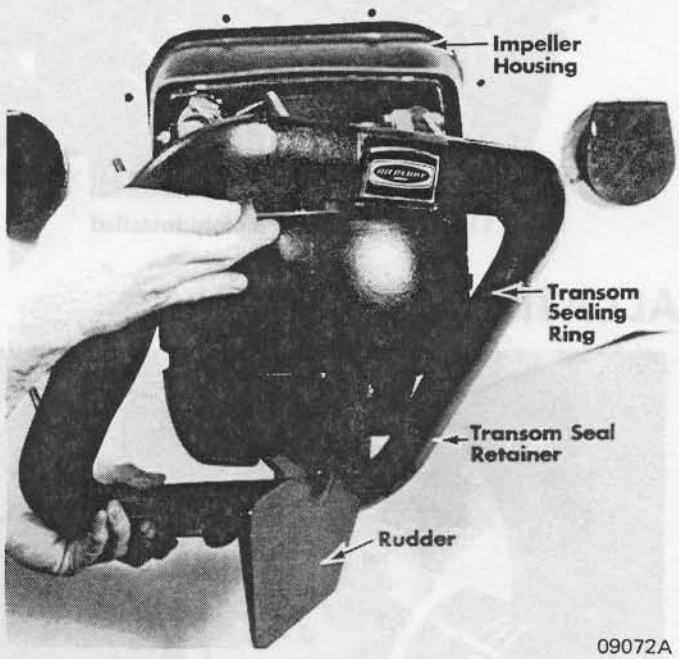


Figure 5. Installing Transom Seal Retainer Assembly

7. Install 3 backup plates over transom seal retainer studs. (Figure 6) Install 8 lockwashers and nuts on studs and draw up evenly until snug, then torque nuts to specifications.

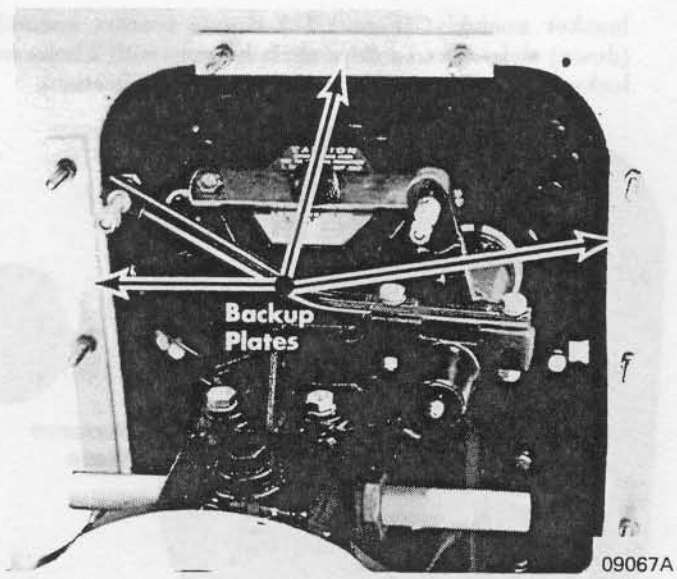


Figure 6. Installing Backup Plates

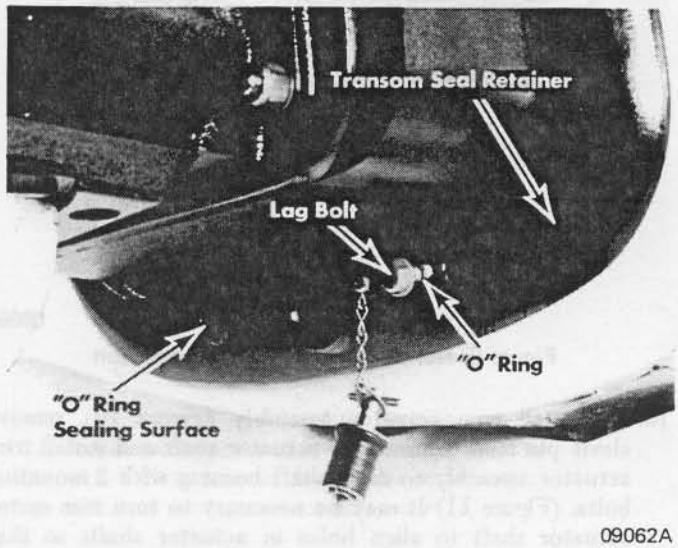


Figure 7. Installing Lag Bolts

8. Apply Silicone Sealer to "O" rings and lag bolts and install them thru bottom holes in transom seal retainer. (Figure 7)
9. To reinstall shift bracket assembly, place assembly in neutral position, as shown in Figure 8. Place reverse gate in position shown (full up) in Figure 9. Be sure that thick rubber seal is in position (Figure 4), then install shift

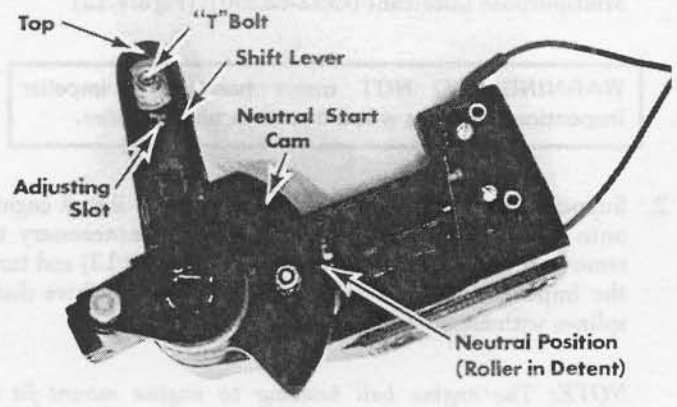


Figure 8. Neutral Position

bracket assembly. (Figure 10) Rotate bracket assembly (down) and secure to drive shaft housing with 2 bolts and lockwashers. (Figure 2) Torque bolts to specifications.

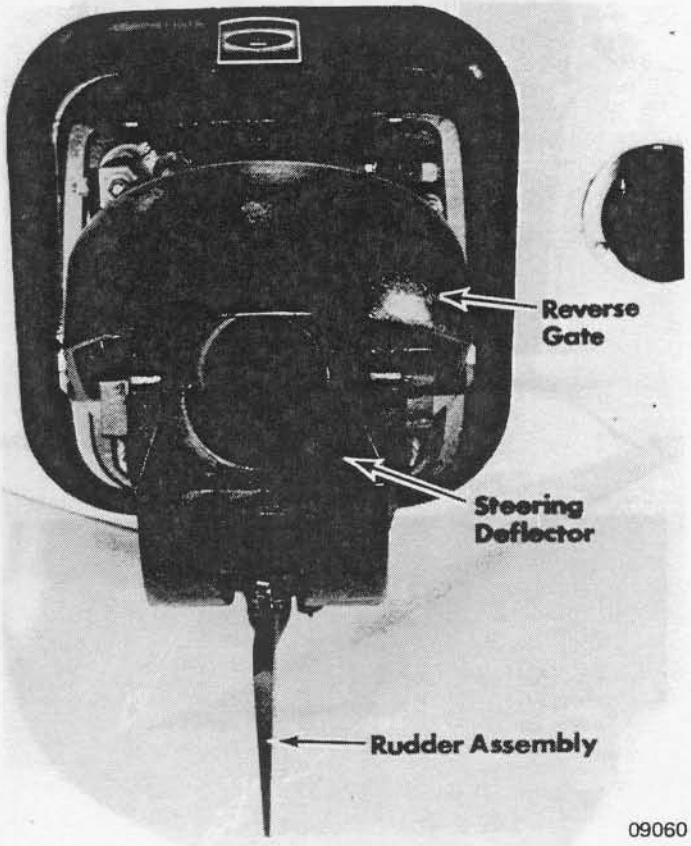


Figure 9. Reverse Gate in Full Up Position

10. To install trim actuator assembly (Figure 10), remove clevis pin from trim motor actuator shaft and install trim actuator assembly to drive shaft housing with 2 mounting bolts. (Figure 11) It may be necessary to turn trim motor actuator shaft to align holes in actuator shafts so that clevis pin can be installed. Install cotter pin and spread ends of cotter pin. Torque 2 mounting bolts to specifications. (Figure 11)
11. Reinstall stator housing cover and secure with 2 attaching bolts.

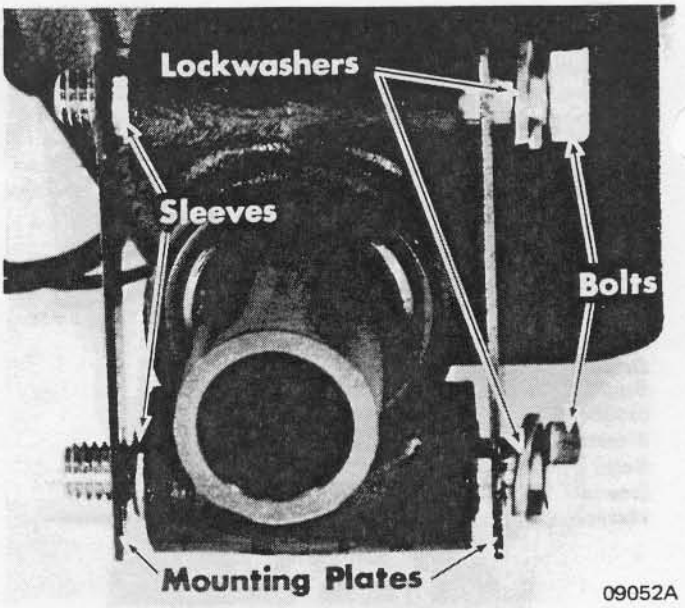


Figure 10. Trim Actuator Assembly

IMPORTANT: Be sure that bolts are tight, or cover could become lost during operation.

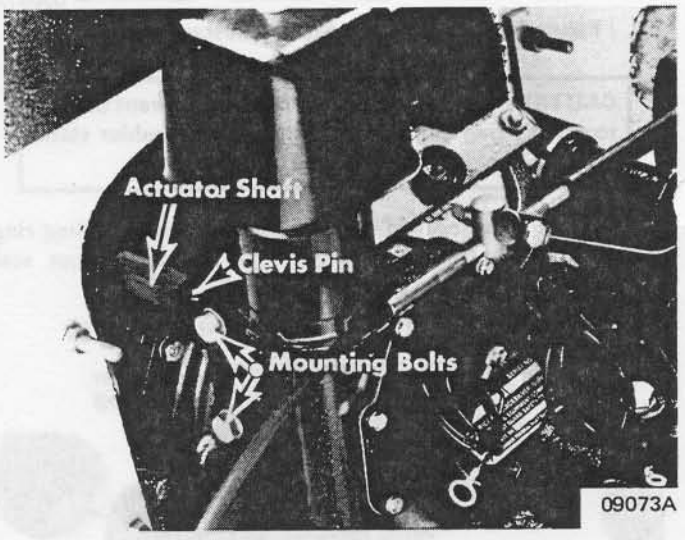


Figure 11. Trim Actuator Assembly Installed

ENGINE INSTALLATION

1. Lubricate drive shaft and engine coupler splines with Multipurpose Lubricant (C-92-63250). (Figure 12)

WARNING: DO NOT insert hands into impeller inspection port. Use wood dowel to turn impeller.

2. Support engine with an overhead hoist and install engine onto drive shaft housing mount. It may be necessary to remove the impeller inspection cover (Figure 13) and turn the impeller (with a wood dowel) to align the drive shaft splines with engine coupler splines.

NOTE: The engine bell housing to engine mount fit is close, so correct engine angle is important for easy installation.

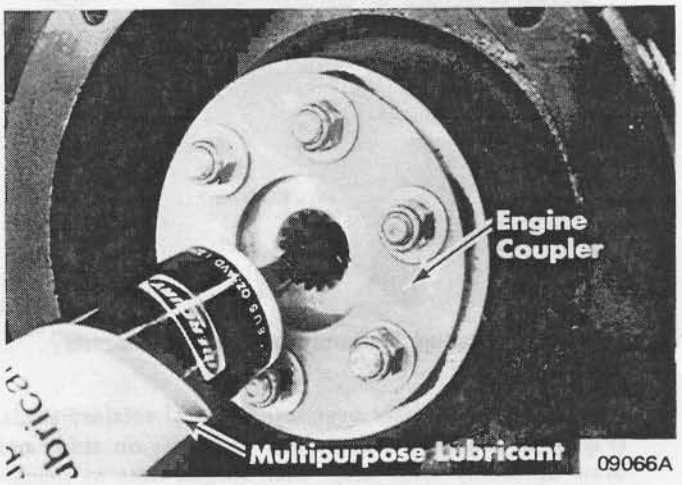


Figure 12. Lubricating Engine Coupler

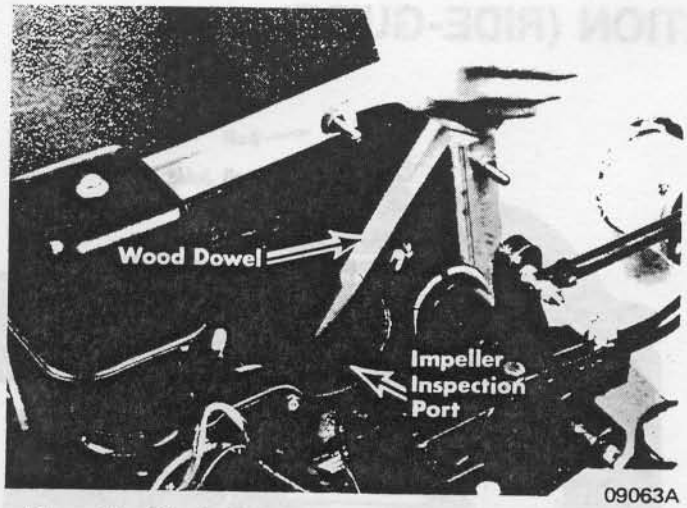


Figure 13. Aligning Drive Shaft Splines with Engine Coupler

3. Install 6 nuts and washers (Figure 14) and torque to specifications.
4. To check engine alignment, visually check the 3 alignment bosses on engine mount (one not shown, Figure 14) for alignment with machined edge of drive shaft housing retainer. (Figure 15) If bosses do not align, adjust engine up-or-down or sideways until bosses are aligned, or that all are an equal distance from machined edge of drive shaft housing retainer.

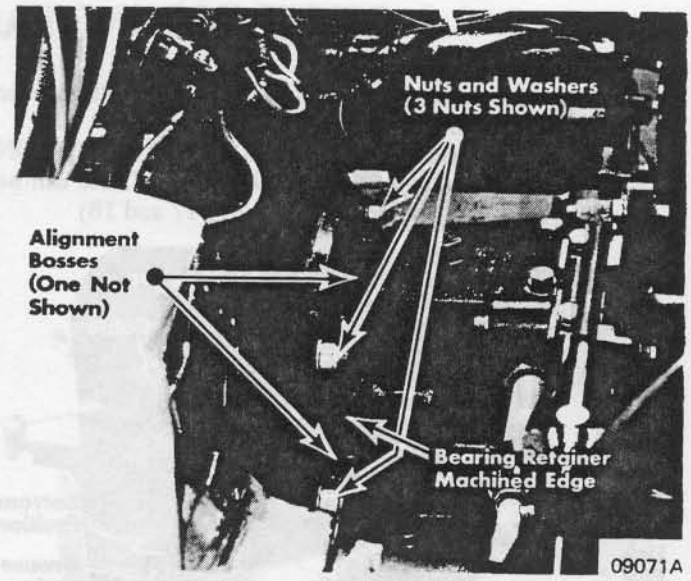


Figure 14. Engine Installed and Aligned

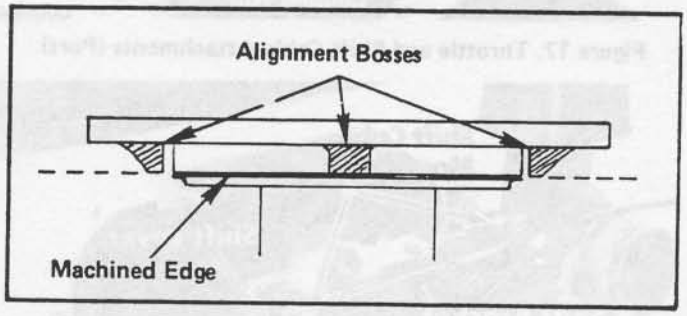
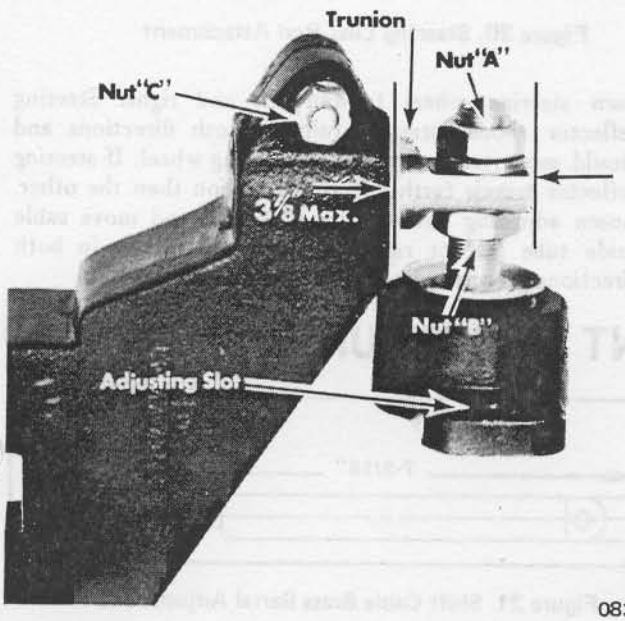


Figure 15. Alignment Boss

ENGINE ALIGNMENT and MOUNTING ADJUSTMENTS

Engine mounts are adjustable to permit raising or lowering engine and also moving engine to right or left. After engine mounts have been fastened to the engine bed, final alignment should be made by adjusting engine mounts as follows:

1. Loosen nut "A" (Figure 16) and turn nut "B" clockwise to lower engine or counterclockwise to raise engine. Retighten nut "A" securely.



2. Loosen nut "C" (Figure 16) on both mounts and move engine to right or left, as required. Mounts must not extend over 3-7/8" (98mm) from mount brackets. Tighten nut securely after completing adjustment. A small amount of right or left adjustment also may be obtained with slot on front side of engine mount. Loosen lag bolts which attach mount to engine bed. Move engine right or left, as required, and tighten lag bolts.

IMPORTANT: Recheck mounting points for tightness after first 20 hours of operation.

Engine is aligned when all 3 alignment bosses (one not shown) are at an equal distance from machined edge of drive shaft housing retainer. (Figures 14 and 15)

Figure 16. Engine Mount Adjustment

STEERING INSTALLATION (RIDE-GUIDE)

1. Lubricate inside of cable guide tube with Multipurpose Lubricant (C-92-63250). (Figures 17 and 18)
2. Insert cable end thru tube, THREAD COUPLER NUT ON GUIDE TUBE and torque to specifications. Cable can be installed from right or left side. (Figures 17 and 18)

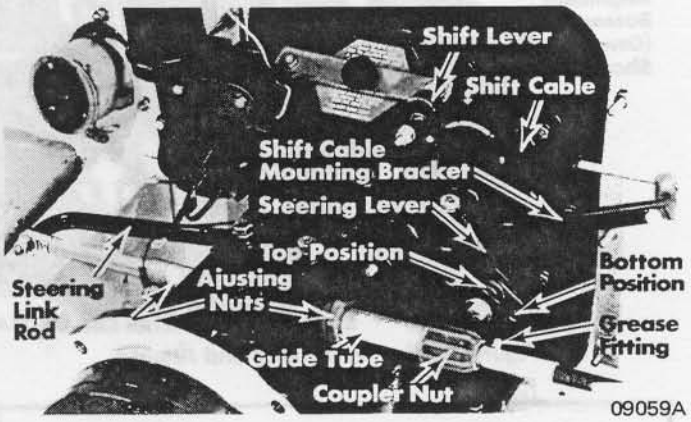


Figure 17. Throttle and Shift Cable Attachments (Port)

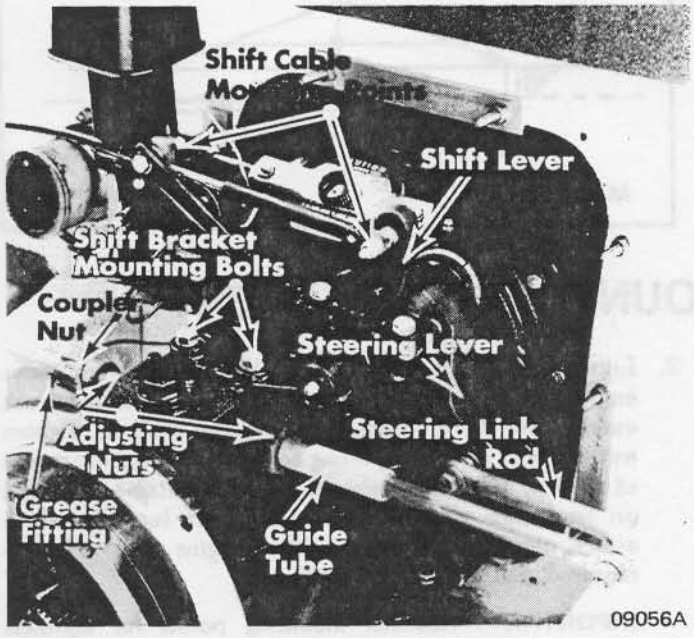


Figure 18. Throttle and Shift Cable Attachments (Starboard)

3. Attach steering link rod to steering lever in bottom hole for standard ratio steering or top hole for quick ratio steering. (Figure 19) Lubricate ball joint with Multipurpose Lubricant. Torque castle nut to specifications. Install cotter pin and spread ends of cotter pin. If cotter pin holes do not align, continue tightening until cotter pin can be installed.

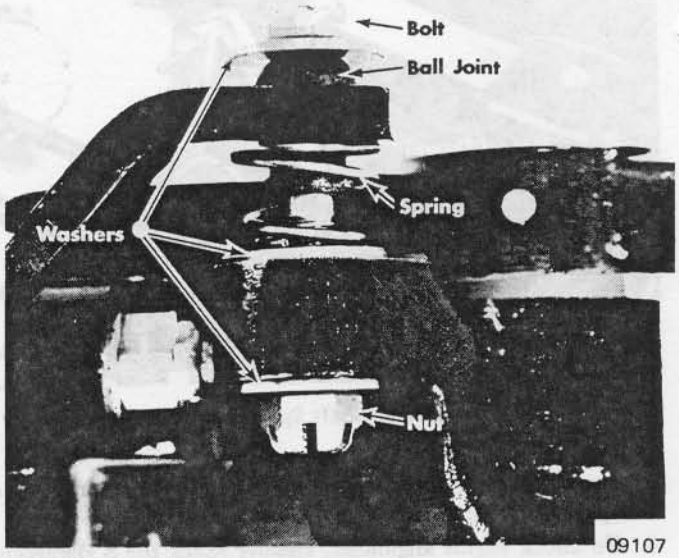


Figure 19. Steering Link Rod Attached to Steering Lever

NOTE: Quick ratio steering position will decrease number of turns necessary on steering wheel to complete a given boat maneuver.

4. Insert link rod thru hole in cable end. Lubricate with Multipurpose Lubricant. Use thick washer as shown in Figure 20. Torque castle nut to specifications, back off nut ¼-turn and install cotter pin, then spread ends of cotter pin.

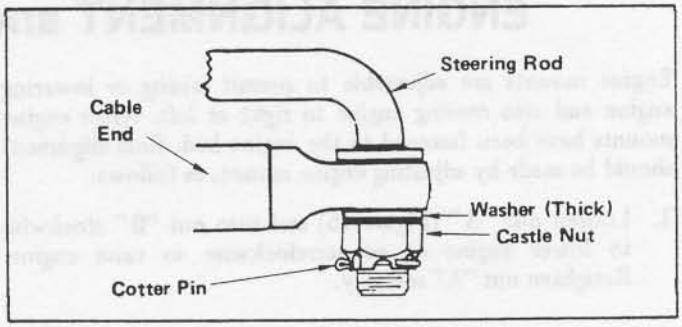


Figure 20. Steering Link Rod Attachment

5. Turn steering wheel to full left and right. Steering deflector should traverse fully in both directions and should move same direction as steering wheel. If steering deflector travels further in one direction than the other, loosen adjusting nuts (Figure 17 or 18) and move cable guide tube left or right to allow full traverse in both directions. Torque adjusting nuts to specifications.

SHIFT CABLE ADJUSTMENT PROCEDURES

1. Place shift control box in neutral position.
2. Adjust shift cable brass barrel to obtain 7-3/16" (18.3cm) between center of brass barrel and center hole in cable end guide. (Figure 21)
3. Place brass barrel onto stud in mounting bracket (Figure 18 for starboard [right] mounting; Figure 17 for port [left] mounting). Install washer and nut and tighten securely.

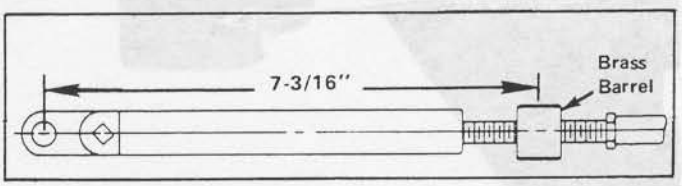


Figure 21. Shift Cable Brass Barrel Adjustment

4. Place shift lever in neutral position, as shown in Figure 8, with neutral start switch roller in detent. Also be sure that "T" bolt is at the "top" of the adjusting slot in shift lever.
5. Loosen nut, that holds shift lever to neutral start cam (Figure 8), move shift lever to allow hole in cable end guide to align with stud on shift lever, then retighten nut. Install cable end on stud. Place washer and elastic stop nut on stud and tighten.
6. Shift the control into reverse position.
7. Reverse gate should just touch steering deflector assembly (Figure 22) with little or no pressure, or hard shifting will occur. If reverse gate does not touch steering deflector assembly, loosen "T" bolt (Figure 8) and slide bolt down adjusting slot until reverse gate is touching steering deflector assembly, then retighten "T" bolt assembly.

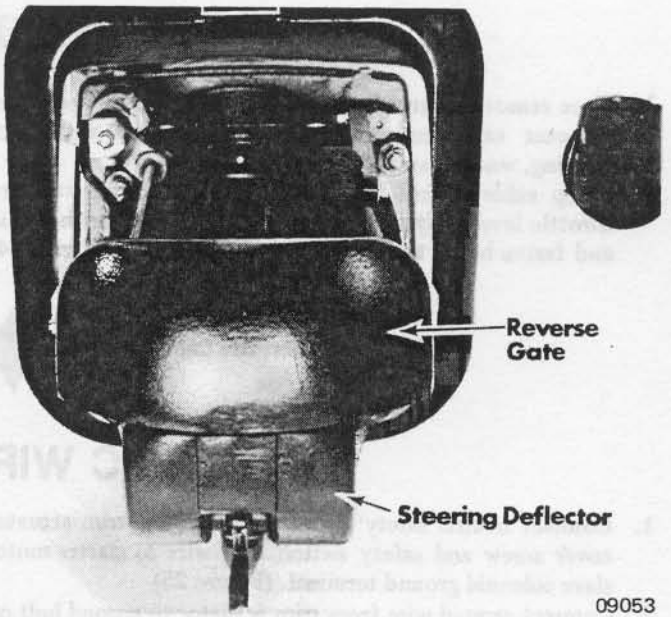


Figure 22. Reverse Gate Touching Steering Deflector

INSTALLING POWER TRIM HARNESS ASSEMBLY

Remove trim motor cover and make electrical connections as shown in Figure 23.

NOTE: Electrical schematic also is shown on decal inside trim motor cover.

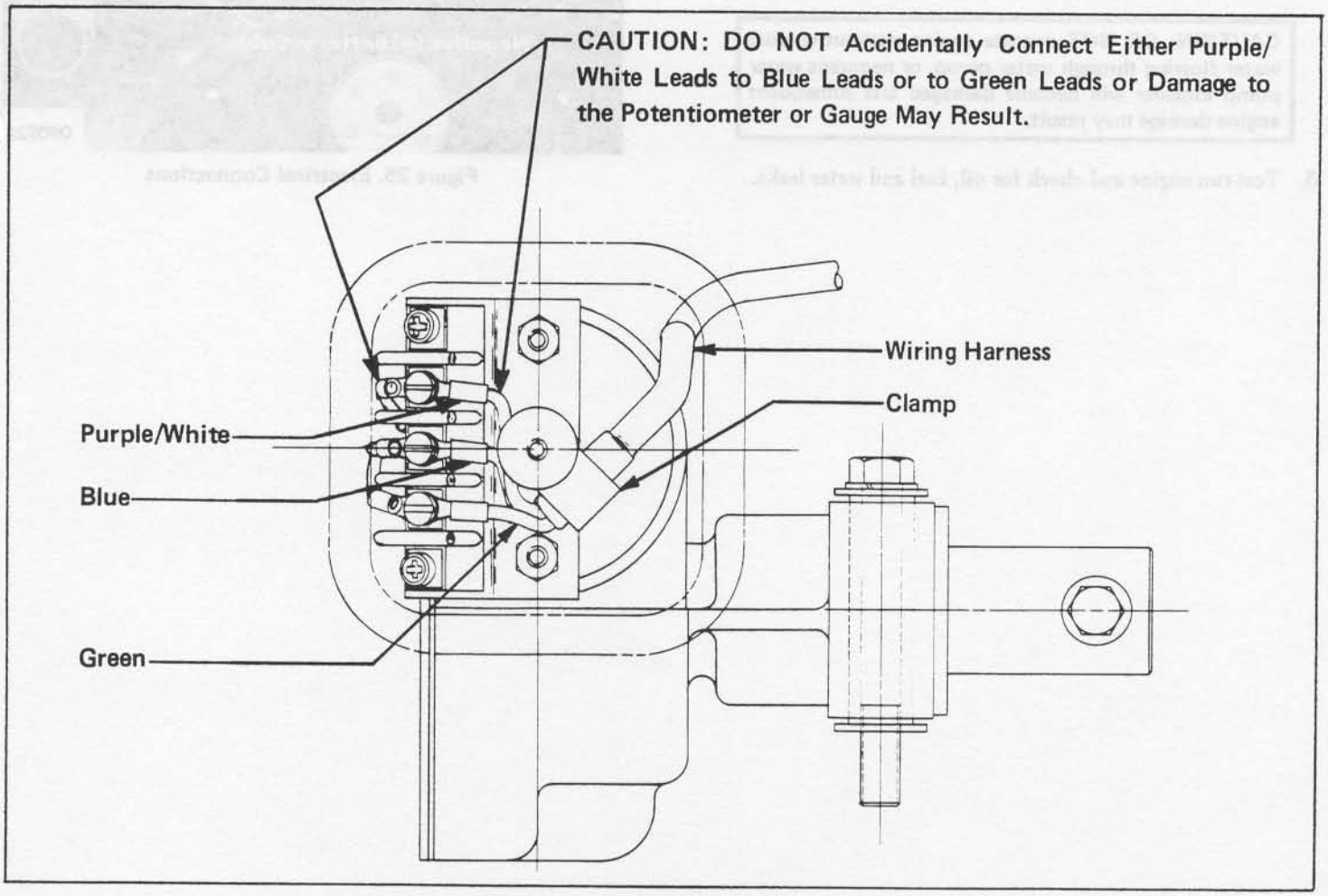


Figure 23. Power Trim Control Panel Schematic

INSTALLING THROTTLE CABLE to ENGINE

1. Place remote control handle in neutral gear, idle position.
2. Connect cable end guide to throttle lever with bolt, bushing, washers and nut. (Figure 24)
3. Grasp cable behind brass barrel and push lightly toward throttle lever. Adjust brass barrel to align with anchor stud and fasten barrel to stud with washers and nut. (Figure 24)

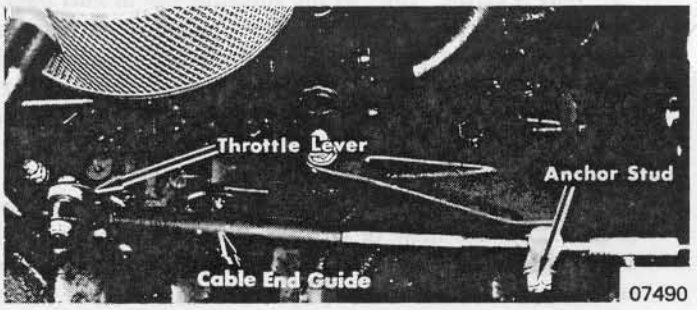


Figure 24. Throttle Cable Installed

ELECTRIC WIRING CONNECTIONS

1. Connect neutral safety switch short wire to trim actuator cover screw and safety switch long wire to starter motor slave solenoid ground terminal. (Figure 25)
2. Connect ground wire from trim actuator to ground bolt on aft end of starboard cylinder head. Battery negative (-) cable is attached to flywheel housing bolt. Battery positive (+) cable is installed to starter solenoid. (Figure 25)
3. Plug in and clamp instrument harness at location shown in Figure 25.
4. Reconnect fuel line, water pickup hose and exhaust hoses.

CAUTION: DO NOT operate engine without cooling water flowing through water pump, or neoprene water pump impeller will become damaged and subsequent engine damage may result.

5. Test-run engine and check for oil, fuel and water leaks.

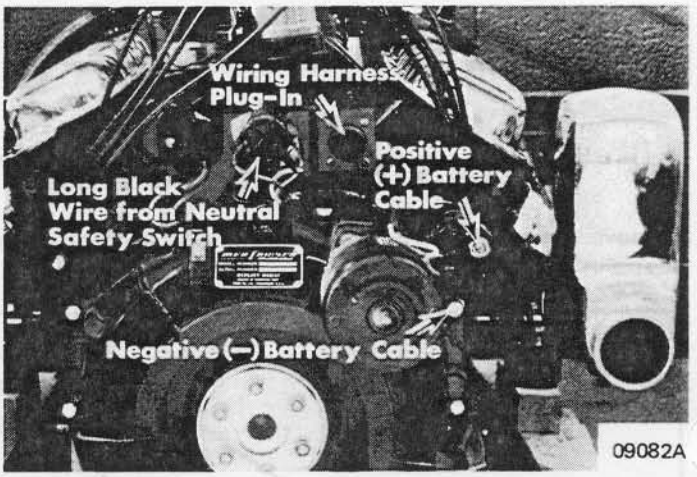


Figure 25. Electrical Connections

JET DRIVE COMPONENTS
GENERAL SERVICE RECOMMENDATIONS

Many components can be removed and serviced without removing jet drive (or portions) from boat. The following includes complete disassembly of jet drive unit.

Instructions are printed in the sequence which will be followed to assure best results when removing or replacing components. Follow "Disassembly" and "Reassembly" procedures as written, however, if complete disassembly is not necessary, start reassembly at point disassembly was stopped. (Use "Index".)

In order to assure correct and durable operation after assembly, it is important that all adjustments and torque value specifications be maintained to the highest degree of accuracy.

Use special service tools, where specified, and use common tools of proper fit when removing and replacing parts. When holding housing or parts in a vise (or by other means), use blocks of wood and/or brass shields to prevent marring parts' surfaces. Pressed on parts require adapting appropriate mandrels and supports for the press used.

To prevent oil leakage, apply Loctite Type "A" (C-92-32609) on outside diameter of all metal case oil seals. When using Loctite on oil seals or threads, surfaces must be clean and dry.

COMPONENT REMOVAL/CLEANING and INSPECTION/DISASSEMBLY

SHIFT BRACKET ASSEMBLY

REMOVAL

1. Disconnect shift cable from jet drive. (Figure 1 or 2)
2. Disconnect neutral start switch leads from engine and trim actuator.
3. Remove 2 bolts and remove shift bracket assembly.

CLEANING and INSPECTION

1. DO NOT clean neutral start switch (Figure 3) in solvent. DO NOT allow solvent to enter switch or remove water sealent from switch outside surface. Switch must be removed to clean bracket assembly.
2. If needed, clean assembly in solvent and dry with compressed air. DO NOT allow solvent to remain on nyliner or nylon washer (Figure 3) for long periods of time, or solvent may soften nylon material.

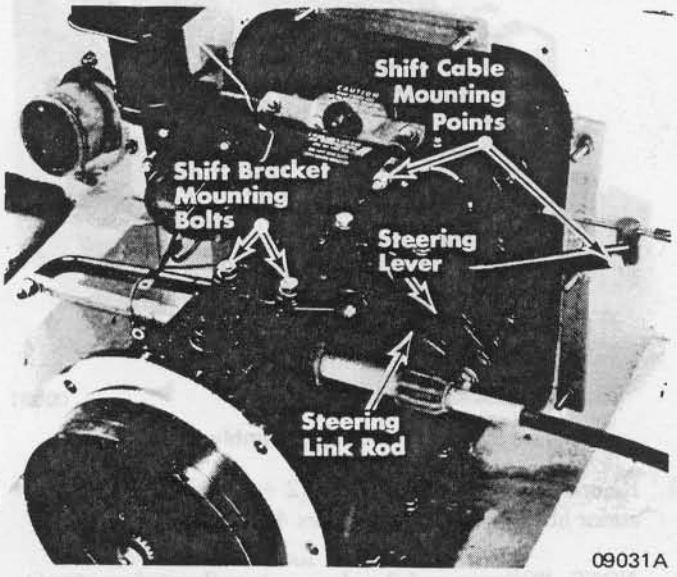


Figure 1. Cable Connections and Shift Bracket Mounting Bolts (Cable Mounting Port [Left] Side)

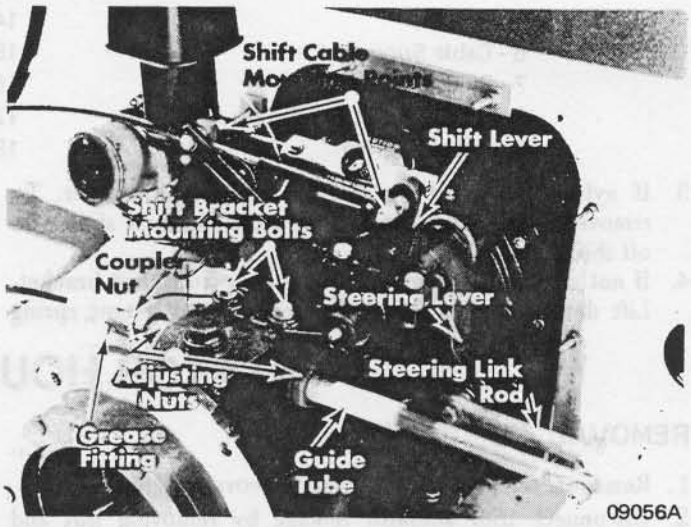


Figure 2. Cable Connections and Shift Bracket Mounting Bolts (Cable Mounting Starboard [Right] Side)

3. Check for excessive play between shift lever and nyliner and nylon washer. (Figure 3) Replace nyliner and nylon washer if worn.
4. Detent shaft must move freely in its slot, and detent roller also must turn freely. (Figure 3)
5. Test neutral start switch with a continuity meter. Connect one test lead to each switch wire. With switch arm not actuated ("out" position), meter should indicate continuity. With switch arm actuated ("in" position) meter should indicate no continuity. Replace switch if defective.
6. Check for broken or damaged parts and replace as needed.

DISASSEMBLY

1. Remove 2 screws and remove neutral start switch assembly.
2. Remove one screw, lockwasher and washer, then remove retainer lever, nylon washer and shift lever and neutral start cam assembly. (Figure 3)

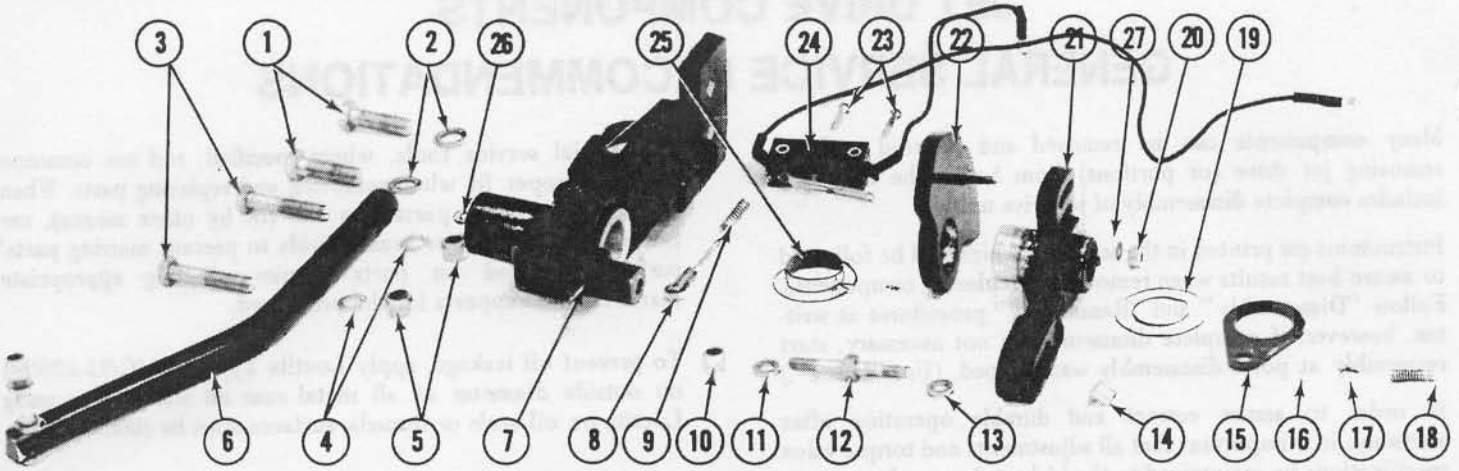


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Figure 3. Shift Bracket Assembly Parts Identification

Parts Identification for Figure 3

1 - Shift Bracket Mounting Bolt (2)
2 - Lockwasher (2)
3 - Cable Support Arm Mounting Bolt (2)
4 - Washer (2)
5 - Nut (2)
6 - Cable Support Arm
7 - Shift Lever Bracket
8 - Detent Shaft and Roller Assembly
9 - Detent Spring
10 - Nut
11 - Washer
12 - Stud
13 - Washer
14 - Tee Nut
15 - Retainer Lever
16 - Washer
17 - Lockwasher
18 - Bolt
19 - Nylon Washer
20 - Neutral Start Cam Stud Nut
21 - Shift Lever
22 - Neutral Start Cam
23 - Screw (2)
24 - Neutral Start Switch Assembly
25 - Nyliner
26 - Grease Fitting
27 - Washer

3. If nyliner remained on shift lever, remove nyliner. To remove neutral start cam, remove one nut and slide cam off shift lever. (Figure 3)
4. If not already removed, remove nyliner from shift bracket. Lift detent shaft and roller assembly and detent spring from its cavity (located in shift bracket).
5. Remove 2 nuts, 2 washers and 2 bolts and remove shift cable support arm.
6. Grease fitting may be removed from shift bracket, if desired.

STATOR HOUSING ASSEMBLY

REMOVAL

1. Remove 2 screws and remove stator cover. (Figure 4)
2. Disconnect trim actuator linkage by removing nut and bolt, shown in Figure 5. Take care not to lose 2 washers, 2 nylon bushings and steel sleeve.

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Figure 4. Stator Cover

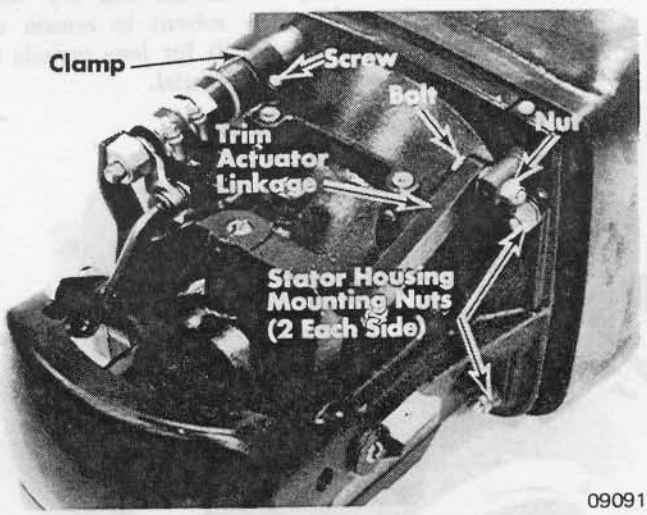

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Figure 5. Stator Housing Assembly Removal

3. Remove 4 nuts and washers (2 each side), then remove stator housing assembly. (Figure 4)

NOTE: "O" ring and 2 nylon washers (located on steering shaft) and large "O" ring (on housings mating surfaces) may stay on either stator or impeller housing.

STEERING TUBE and SHIFT SHAFT

REMOVAL

NOTE: Shift shaft and steering tube assemblies should not be removed without removing stator housing assembly.

1. Remove nut, washer and spring from reverse gate link. (Figure 6)

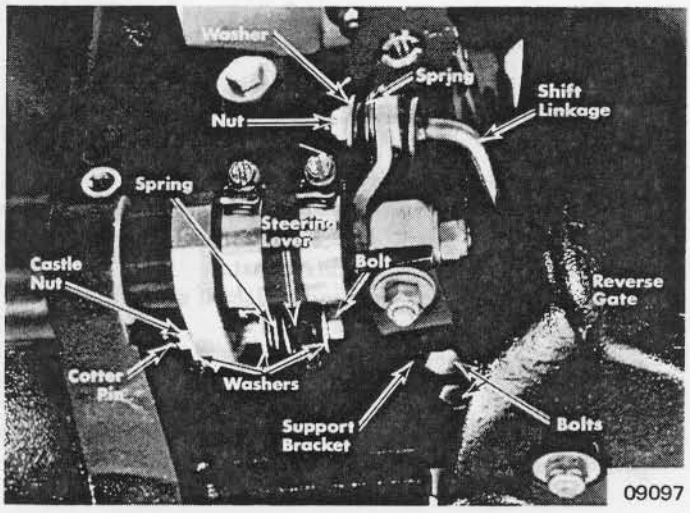


Figure 6. Removing Shift Shaft and Steering Tube

2. Remove 2 nuts, 2 washers and 2 bolts and lift out shift shaft support bracket. (Figure 6)
3. Remove cotter pin, castle nut, 3 washers and bolt from steering lever. (Figure 6)
4. Loosen screw on steering tube clamp. (Figure 5)
5. Shift shaft may be removed by itself, or shift shaft and steering tube may be removed as an assembly. Pull tube and/or shaft out thru stator housing.

DISASSEMBLY

To disassemble shift shaft and steering tube assembly, use Figure 7 for sequence and parts identification.

CLEANING and INSPECTION

CAUTION: DO NOT clean nylon, rubber or plastic parts in cleaning solvent.

1. Clean metal parts in cleaning solvent and dry with compressed air.
2. Inspect "O" rings, seals and nylon washers for wear, cuts, tears and roughness on sealing surface.
3. Check bushings for wear and replace if needed.

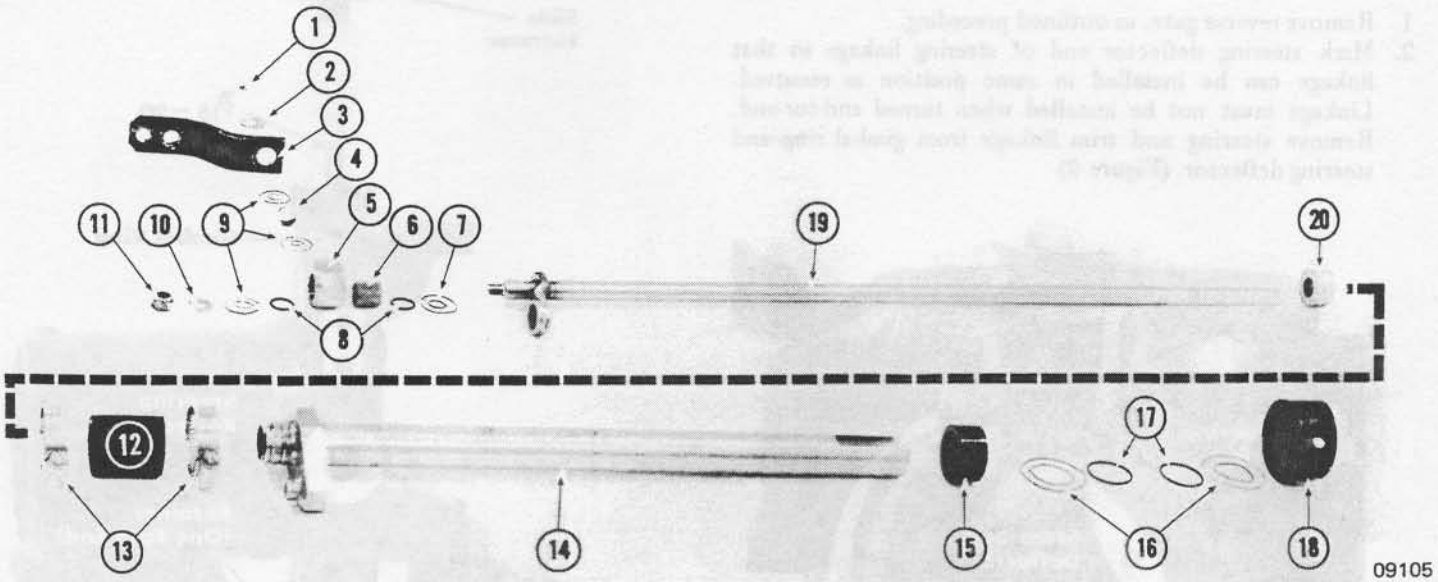


Figure 7. Steering Tube and Shift Shaft Assembly

Parts Identification for Figure 7

1 - Nut
2 - Washer
3 - Steering Lever
4 - Spacer
5 - Bushing Block
6 - Bushing
7 - Nylon Washer
8 - "O" Rings
9 - Nylon Washers
10 - Washer
11 - Nut
12 - Seal Retainer Hose
13 - Clamps
14 - Steering Tube
15 - Bushing
16 - Nylon Washers
17 - "O" Rings
18 - Clamp
19 - Shift Shaft
20 - Seal Retainer with Seals and Scraper

REVERSE GATE

REMOVAL

NOTE: Reverse gate can be removed without removal of other components.

1. Disconnect shift linkage from port (left) side of reverse gate. (Figure 8)

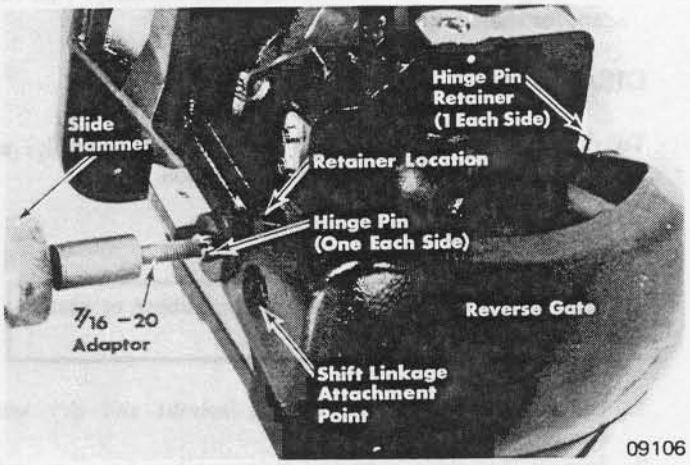


Figure 8. Removing Reverse Gate

2. Remove hinge pin retainer (one each side). (Figure 8)
3. Use Slide Hammer (C-91-34569A1) with appropriat adaptor (7/16-20 thread size) (Figure 8) or use Slide Hammer (with 3-jaw puller) and bolt with 7/16-20 thread size to remove reverse gate hinge pins (one each side). DO NOT lose nylon washers (one each side).
4. Steering deflector housing and gimbal ring also are free from stator housing and can be removed at this time. DO NOT lose nylon washers (one each side).

CLEANING and INSPECTION

1. Clean in solvent and dry with compressed air.
2. Remove any corrosion from housing surface and inspect condition of paint. Use a primer paint on bare metal surfaces before applying finish coat.
3. Check bushings for wear and replace if needed.

DISASSEMBLY

Use an appropriate adaptor and press bushings from reverse gate. Be sure to support housing while pressing.

GIMBAL RING

REMOVAL

1. Remove reverse gate, as outlined preceding.
2. Mark steering deflector end of steering linkage so that linkage can be installed in same position as removed. Linkage must not be installed when turned end-for-end. Remove steering and trim linkage from gimbal ring and steering deflector. (Figure 9)

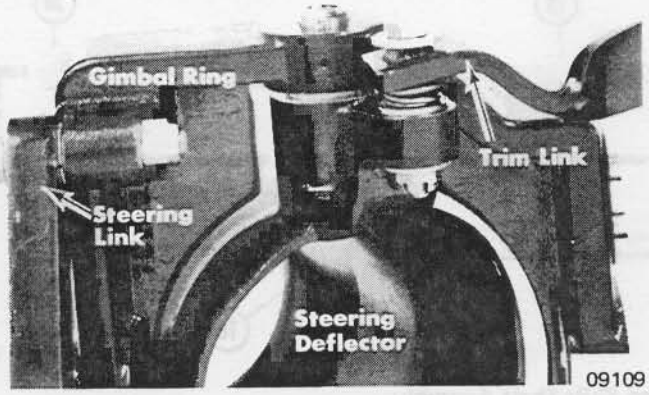


Figure 9. Steering and Trim Linkage

3. Remove hinge pin retainer (one each, top and bottom). (Figure 10)
4. Use Slide Hammer (C-91-34569A1) with appropriate adaptor (7/16-20 thread size) (Figure 9) or use Slide Hammer (with 3-jaw puller) and bolt with 7/16-20 thread size to remove hinge pins (one each, top and bottom) from gimbal ring.
5. Remove gimbal ring from steering deflector. DO NOT lose nylon washers.

CLEANING and INSPECTION

1. Clean in solvent and dry with compressed air.

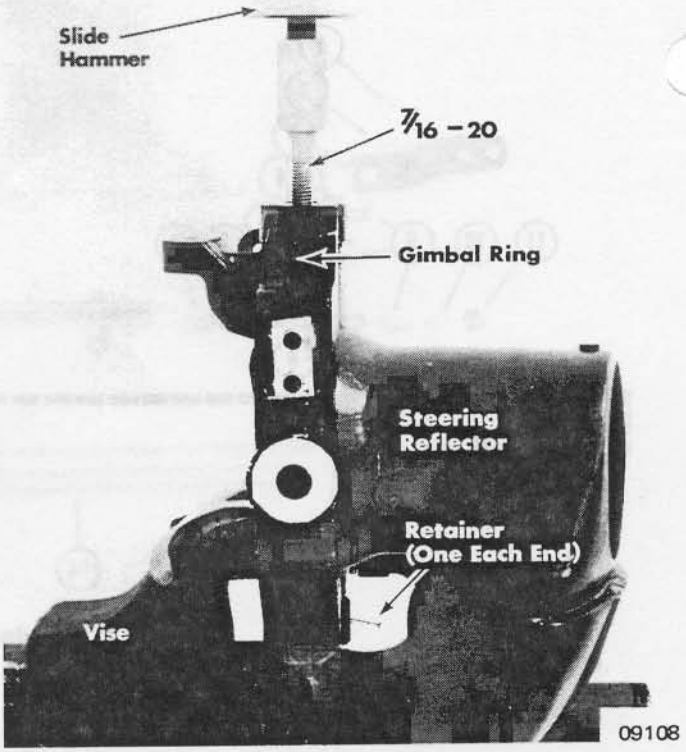


Figure 10. Removing Hinge Pin

2. Remove any corrosion from gimbal ring.
3. Inspect condition of paint. Use a primer paint on bare metal surfaces before applying finish coat.
4. Check bushings for wear and replace if needed.

DISASSEMBLY

Support gimbal ring and press bushings from ring with appropriate adaptor.

STEERING DEFLECTOR

REMOVAL

1. Remove reverse gate as outlined, preceding.
2. Remove gimbal ring as outlined, preceding.

CLEANING and INSPECTION

1. Refer to "Cleaning and Inspection" under "Gimbal Ring", preceding.
2. Check rudder guide buttons for excessive wear.

DISASSEMBLY

1. Support housing and press bushings from housing with appropriate adaptor.
2. Remove rudder guide flat-head buttons and rubber inserts.

RUDDER and MOUNT ASSEMBLY

REMOVAL

NOTE: Rudder and mount assembly can be removed without removal of other components.

Remove 4 bolts with nuts and washers and remove rudder and mount assembly from stator housing. (Figure 11)

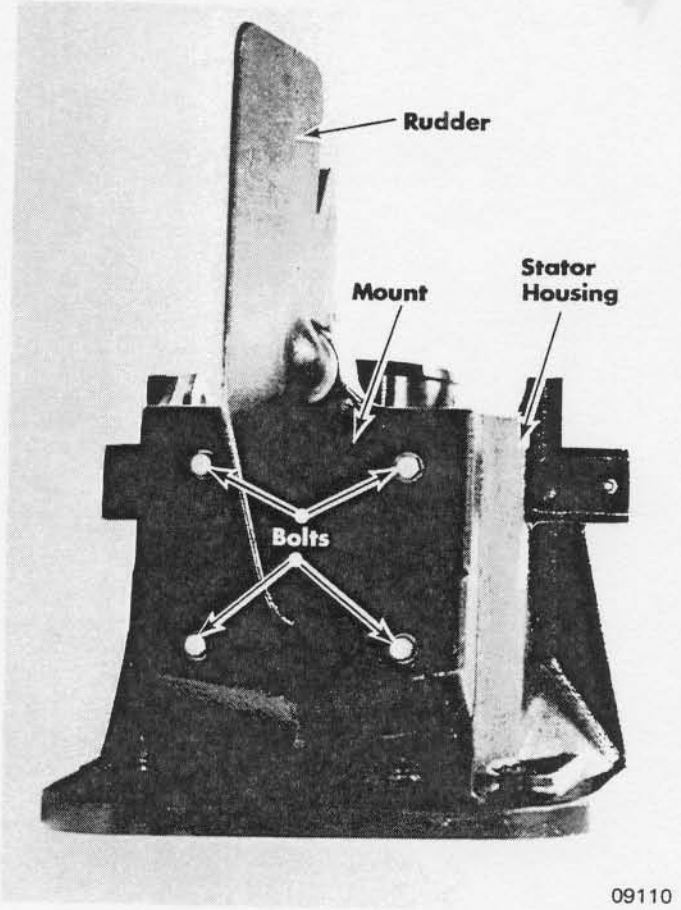


Figure 11. Removing Rudder and Mount Assembly

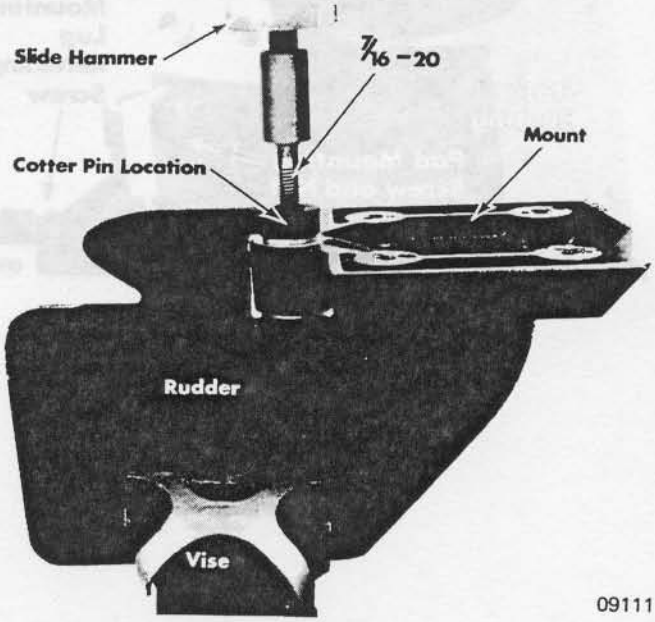


Figure 12. Removing Rudder Pivot Pin

CLEANING and INSPECTION

1. Refer to "Cleaning and Inspection" under "Gimbal Ring", preceding.
2. Check rudder for impact damage (broken, bent condition, etc). Replace or repair as needed.

DISASSEMBLY

1. Remove cotter pin from rudder pivot pin. (Figure 12)
2. Use Slide Hammer (C-91-34569A1) with appropriate adaptor (7/16-20 thread size) (Figure 12) or use Slide Hammer (with 3-jaw puller) and bolt with 7/16-20 thread size to remove pivot pins.
3. Remove rudder from mount. DO NOT lose nylon washers.
4. Press bushing from mount assembly with proper adaptor.

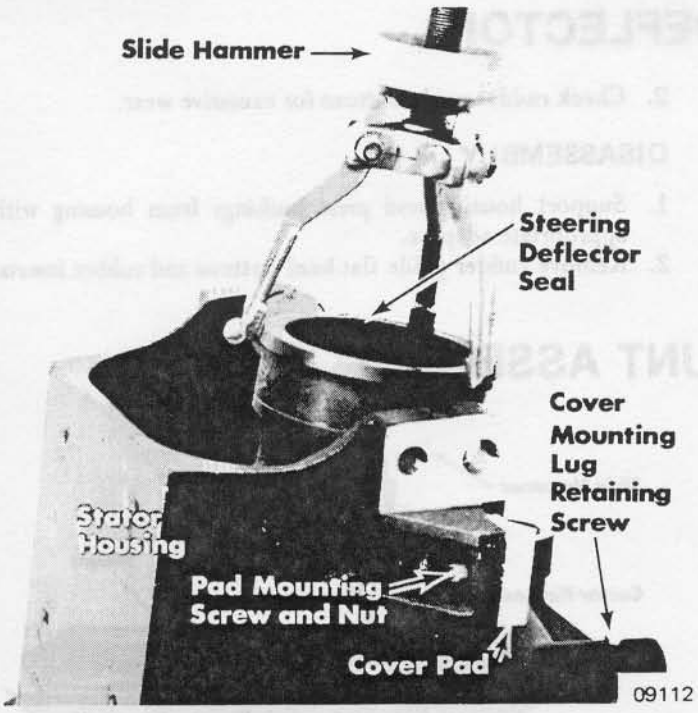
STATOR HOUSING ASSEMBLY

CLEANING and INSPECTION

1. Clean assembly with solvent and dry with compressed air. DO NOT allow solvent to remain on nonmetal parts for long periods of time.
2. Remove any corrosion and check condition of paint. Use primer paint on bare metal surfaces before applying finish coat.
3. Check condition of deflector housing seal and cover pads.
4. Check condition of steering tube bushing.

DISASSEMBLY

1. Use Slide Hammer (C-91-34569A1) to remove steering deflector housing seal. (Figure 13)



2. Stator cover mounting lugs may be removed by removing lug retaining screws (one each side of housing). (Figure 13)
3. Stator housing cover pads (one each side) may be lifted off by removing its mounting screw and nut. (Figure 13)
4. To remove flat head buttons (small cover pads), pry out or carefully use a drill. DO NOT enlarge holes.
5. Push steering tube bushing out of boss.

Figure 13. Stator Housing Disassembly

COMPONENT REASSEMBLY/INSTALLATION

STATOR HOUSING REASSEMBLY

1. If removed, install new flat-head buttons (small stator cover pads), using Epoxy Kit (C-92-33673). (Figure 1)
2. Place stator housing cover pads (one each side) in position on stator housing. Raised side of pad faces up and to outside of housing. (Figure 1) Fasten pads with mounting screws and nuts.
3. Fasten stator cover mounting lugs (one each side) with lug retaining screws and nuts. (Figure 1) Torque nuts to "Specifications", following.
4. Press or tap steering deflector housing seal unto stator housing until it bottoms-out on housing shoulder. (Figure 1)
5. Install steering tube bushing (Figure 1) into bushing cavity until centered, using Multipurpose Lubricant.

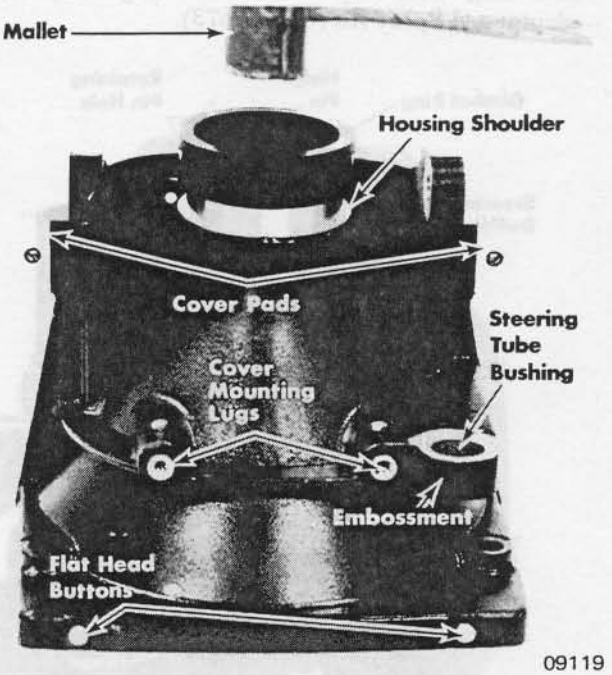


Figure 1. Stator Housing Assembly

STEERING DEFLECTOR

REASSEMBLY

1. Apply Multipurpose Lubricant (C-92-63250) to flat-head buttons and rubber inserts. (Figure 2) Install rubber insert and button on one side, then install other insert part way (at angle shown in Figure 2) and install second button, while further installing rubber insert at same time.
2. Use Epoxy Kit (C-92-33673) and press or drive bushings (top and bottom) into housing until they bottom-out. Support housing while installing bushing.

INSTALLATION

Refer to "Gimbal Ring Installation", following.

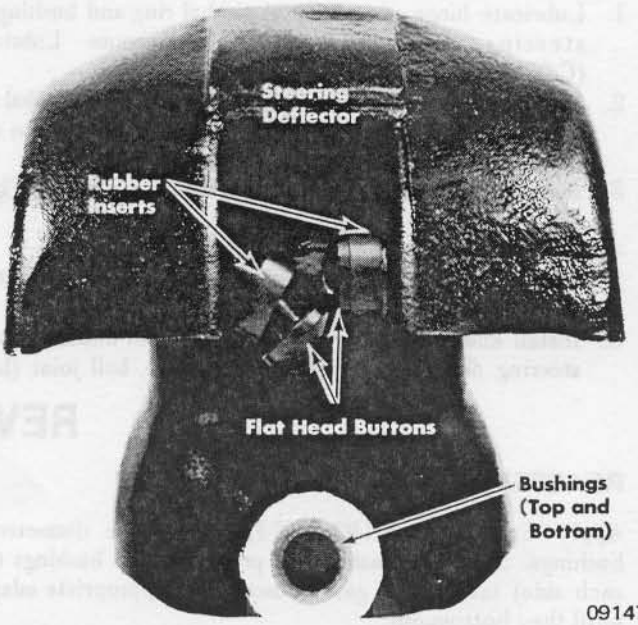


Figure 2. Steering Deflector Assembly

GIMBAL RING

REASSEMBLY

Support gimbal ring and press or drive bushings into ring (one each side) until they bottom-out. (Figure 3) Use proper adaptor and Epoxy Kit (C-92-33673).

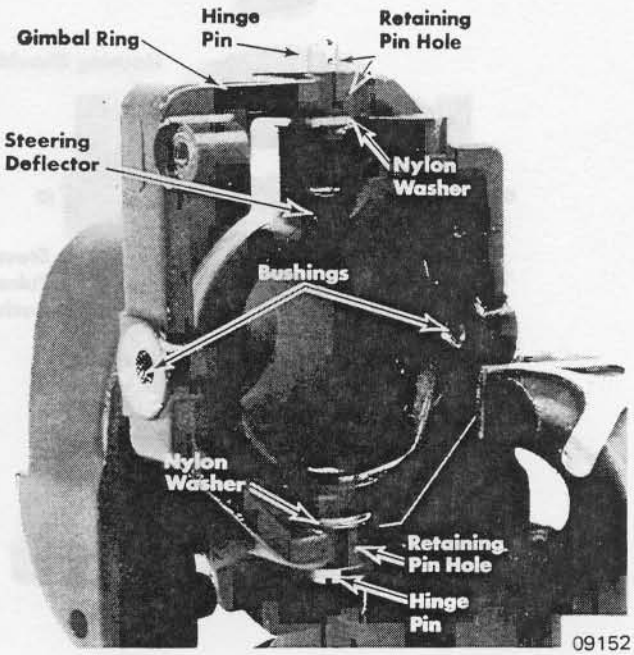


Figure 3. Installing Steering Deflector on Gimbal Ring

INSTALLATION

1. Lubricate hinge pin cavity in gimbal ring and bushings in steering deflector with Multipurpose Lubricant (C-92-63250).
2. Place nylon washers (top and bottom) between gimbal ring and steering deflector. (Figure 3) Multipurpose also may be used to hold nylon washer in place.
3. Install hinge pins while aligning retaining pin holes. (Figure 3)
4. Install and bend over end of retaining pin.
5. Install trim linkage to gimbal ring, as shown in Figure 4. Torque nut to "Specifications", following.
6. Install end of steering linkage (marked in disassembly) to steering deflector with bolt, 3 washers, ball joint (lubricated liberally with Multipurpose Lubricant, C-92-63250), spring (large diameter end facing steering linkage), nut and cotter pin. (Figure 5) Torque nut to "Specifications" and install cotter pin. (If cotter pin holes do not align, torque higher until they do.)
7. For gimbal ring installation to stator housing, refer to "Reverse Gate Installation", following.

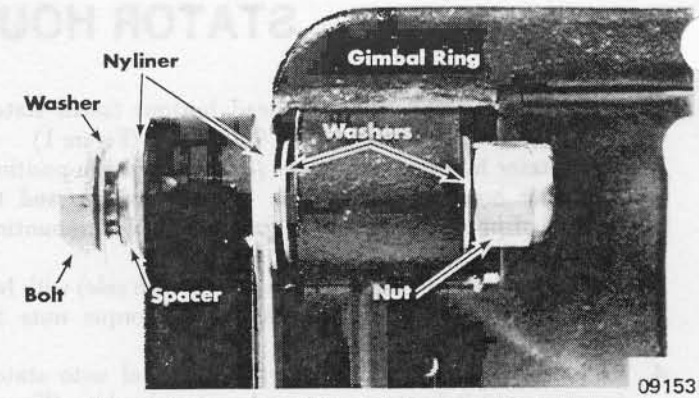


Figure 4. Installing Trim Linkage to Gimbal Ring

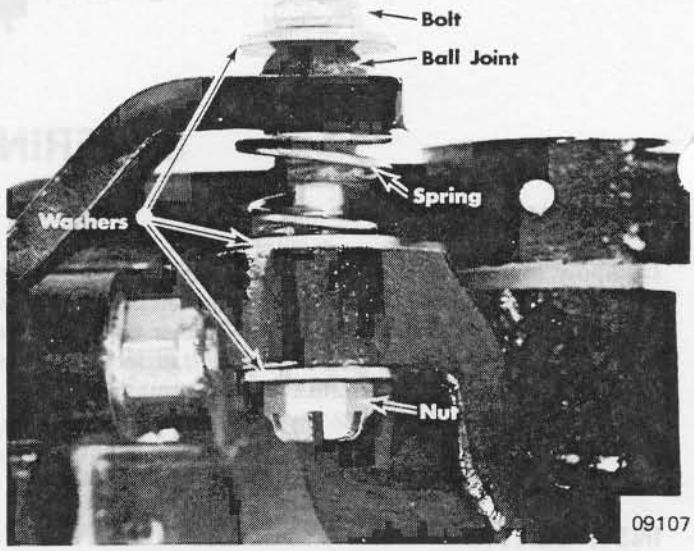


Figure 5. Installing Steering Linkage to Steering Deflector

REVERSE GATE

REASSEMBLY

Apply Epoxy Kit (C-92-33673) to outside diameter of bushings. Support housing and press or drive bushings (one each side) into reverse gate housing with appropriate adaptor until they bottom-out.

INSTALLATION

1. Place 2 nylon washers (one each side) in recess of gimbal ring. Place 2 nylon washers (one each side) in recess in reverse gate. (Figure 6) Multipurpose Lubricant may be used to hold washers in place. Also lubricate inside diameter of bushings.
2. Position gimbal ring assembly and reverse gate onto stator housing. Lubricate and install hinge pins and retainer pins. Bend end of retainer pin after installation. (Figure 6)

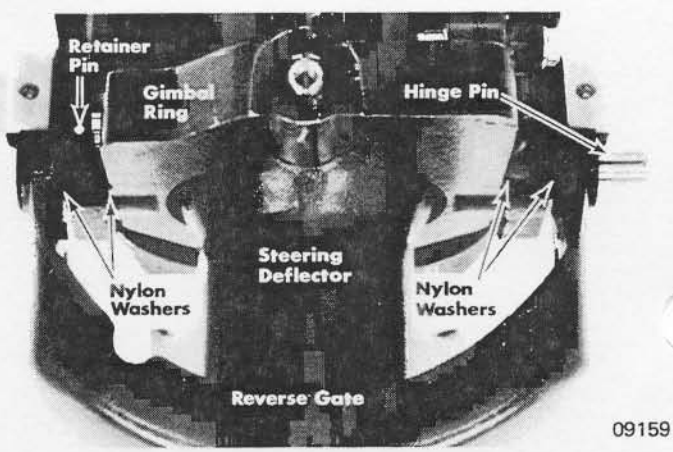


Figure 6. Installing Gimbal Ring and Reverse Gate

RUDDER and MOUNT ASSEMBLY

REASSEMBLY

1. Use Epoxy Kit (C-92-33673) and press or drive bushing into rudder mount until flush. Lubricate bushing with Multipurpose Lubricant (C-92-63250).
2. Assemble rudder and rudder mount with 2 nylon washers (one each side of mount), hinge pin and retainer pin. (Figure 7) Bend end of retainer pin after installation.

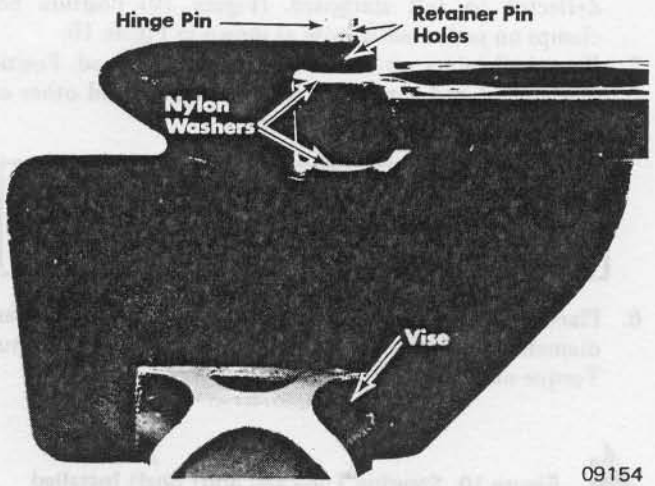


Figure 7. Rudder and Rudder Mount Assembly

INSTALLATION

Lubricate head of flat head buttons (rudder guides). Position rudder and mount assembly on stator housing and fasten assembly with 4 bolts, washers and nuts. (Figure 8) Place washers on bolts and insert from bottom up, with nuts on inside. Torque bolts to "Specifications", following.

Figure 8. Installing Rudder and Mount Assembly on Stator Housing

STEERING and SHIFT SHAFT ASSEMBLY

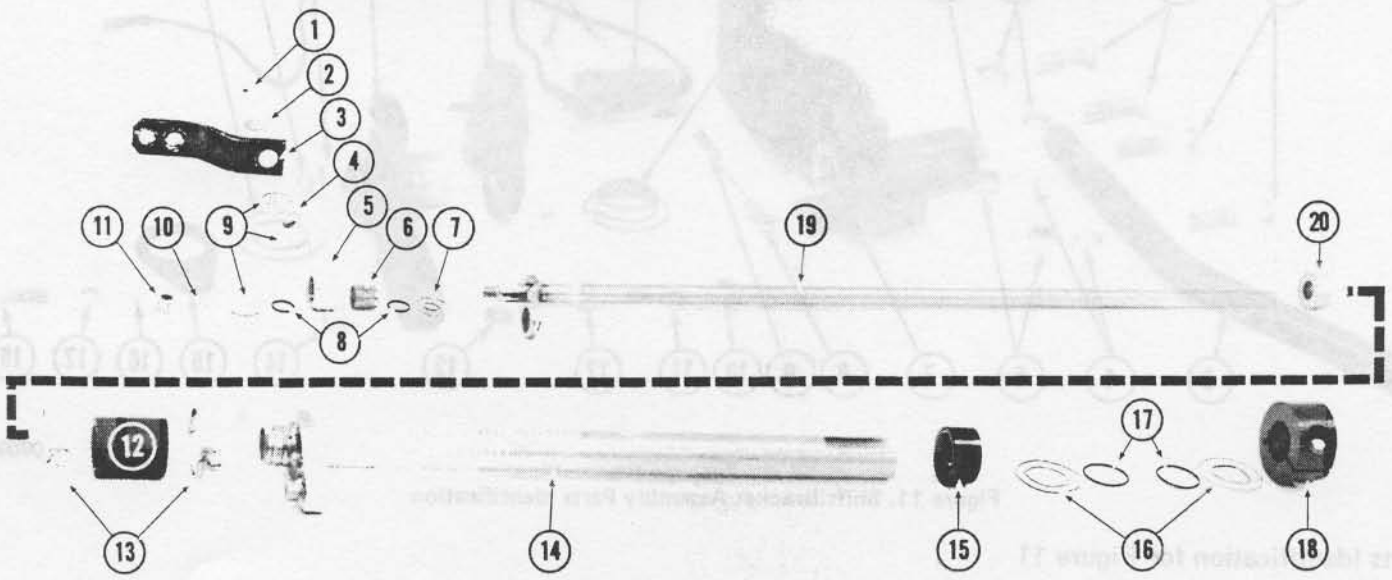


Figure 9. Steering Tube and Shift Shaft Assembly

Parts Identification for Figure 9

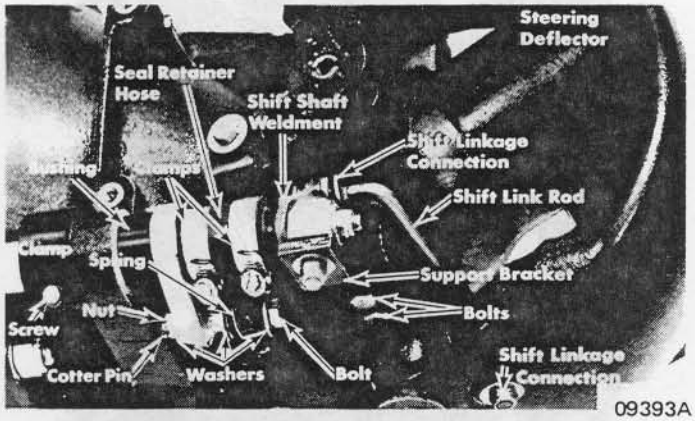
1 - Nut
2 - Washer
3 - Shift Shaft Support Bracket
4 - Spacer
5 - Bushing Block
6 - Bushing
7 - Nylon Washer
8 - "O" Rings
9 - Nylon Washers
10 - Wasner
11 - Nut
12 - Seal Retainer Hose
13 - Clamps
14 - Steering Tube
15 - Bushing
16 - Nylon Washers
17 - "O" Rings
18 - Clamp
19 - Shift Shaft
20 - Seal Retainer with Seals and Scraper

REASSEMBLY

Assemble steering and shift shaft assembly in order shown in Figure 9. Assemble "O" rings and nylon washers (reference No. 16 and 17, Figure 9), one each side of steering tube embossment. Lubricate "O" rings, bushings and oil seals with Multipurpose Lubricant (C-92-63250) during reassembly. Torque 5/16-24 nut and ½-20 nut to "Specifications", following.

INSTALLATION

1. Insert steering tube and shift shaft assembly thru its mounting holes in stator housing. (Figure 10)
2. Bolt shift shaft support bracket to gimbal ring with 2 bolts, 2 sleeves, washers and nuts. (Figure 10) Torque bolts to "Specifications", following.



3. Connect steering linkage to steering tube assembly with bolt, 3 washers, ball joint, spring, (large diameter facing steering linkage), castle nut and cotter pin. (Figure 10) Torque nut to "Specifications" and install cotter pin. If cotter pin holes do not align, torque higher until they do.
4. Push steering tube assembly toward front end of stator housing to eliminate any clearance on either side of steering tube bushing. (Figure 10) Move steering tube clamp against tube support (in position shown) and torque clamp screw to "Specifications" to secure clamp to steering tube. (Figure 10) Turn aft end of steering deflector to full starboard. (Figure 10) Position hose clamps on seal retainer hose as shown in Figure 10.
5. Place ball joints on both ends of shift link rod. Position one end of rod thru shift shaft weldment and other end thru mounting hole in reverse gate.

CAUTION: When torquing nuts, DO NOT allow spring to lodge between ball joint and washer, or nut will not thread far enough onto link rod.

6. Place one spring on each end of link rod, with large diameter of spring on rod first. Install washers and nuts. Torque nuts to "Specifications".

Figure 10. Steering Tube and Shift Shaft Installed

STATOR HOUSING ASSEMBLY

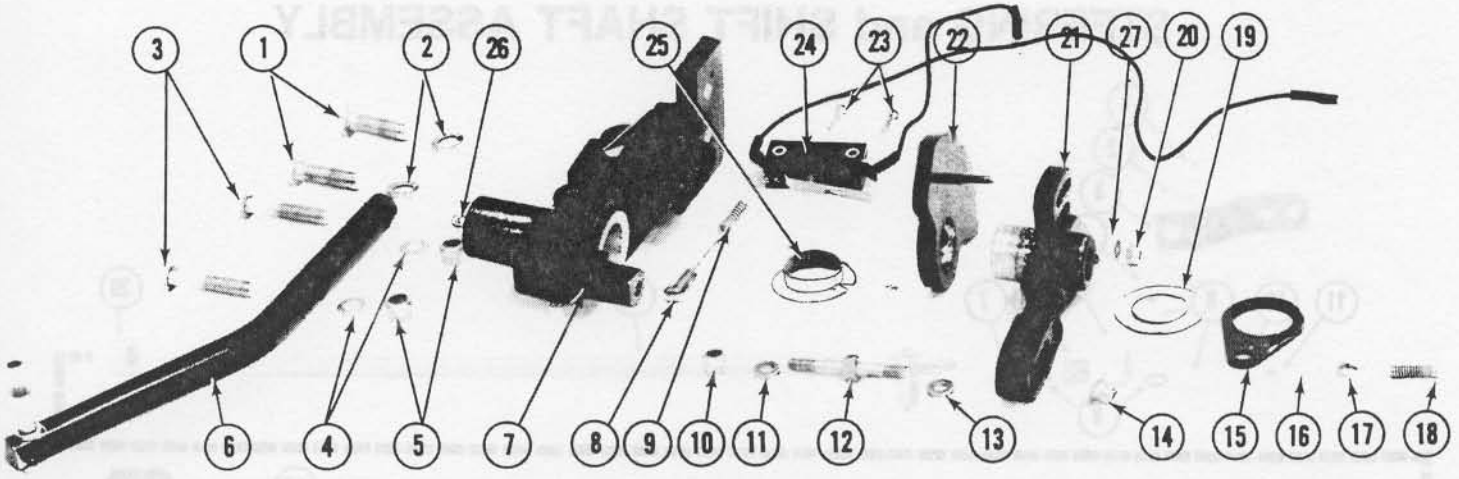


Figure 11. Shift Bracket Assembly Parts Identification

Parts Identification for Figure 11

1 - Shift Bracket Mounting Bolt (2)
2 - Lockwasher (2)
3 - Cable Support Arm Mounting Bolts
4 - Washer (2)
5 - Nut (2)
6 - Cable Support Arm
7 - Shift Lever Bracket
8 - Detent Shaft and Roller Assembly
9 - Detent Spring
10 - Nut
11 - Washer
12 - Stud
13 - Washer
14 - Tee Nut
15 - Retainer
16 - Washer
17 - Lockwasher
18 - Bolt
19 - Nylon Washer
20 - Neutral Start Cam Stud Nut
21 - Shift Lever
22 - Neutral Start Cam
23 - Screw (2)
24 - Neutral Start Switch
25 - Nyliner
26 - Grease Fitting
27 - Washer

INSTALLATION

1. Place 2 nylon washers (with "O" ring between) on steering tube. Be careful not to cut "O" ring on steering tube slots.
2. Position stator assembly on impeller housing studs. Install 4 nuts and washers (2 each side) and torque nuts to "Specifications". (Figure 14)

Figure 14. Stator Housing Assembly Installation

Figure 15. Stator Cover

3. Connect trim actuator linkage by installing steel sleeve, 2 nylon bushings, 2 washers and bolt. Torque bolt to "Specifications". (Figure 14) Lubricate parts with Multipurpose Lubricant (C-92-63250).
4. Install stator cover and tighten mounting screws securely. (Figure 15)

SHIFT BRACKET ASSEMBLY

REASSEMBLY

Lubricate nyliner and nylon washer with Multipurpose Lubricant. Assemble parts in order shown in Figure 11. Torque nuts to "Specifications", following.

INSTALLATION

1. Slide steering lever unto steering tube (if not already installed). Be sure that thick rubber seal is in position on steering tube.
2. To reinstall shift bracket assembly, place assembly in neutral position (neutral detent in recess). Place reverse gate in full "up" position. Place shift bracket assembly onto end of shift shaft. Install shift bracket mounting bolts and lockwashers. (Figure 12 or 13) Torque bolts to "Specifications".
3. Connect steering link rod and shift cable. For shift cable adjustment, refer to "Jet Drive Installation" (see "Index").
4. Lubricate steering tube bushing and shift shaft thru grease fittings with Multipurpose Lubricant (C-92-63250).

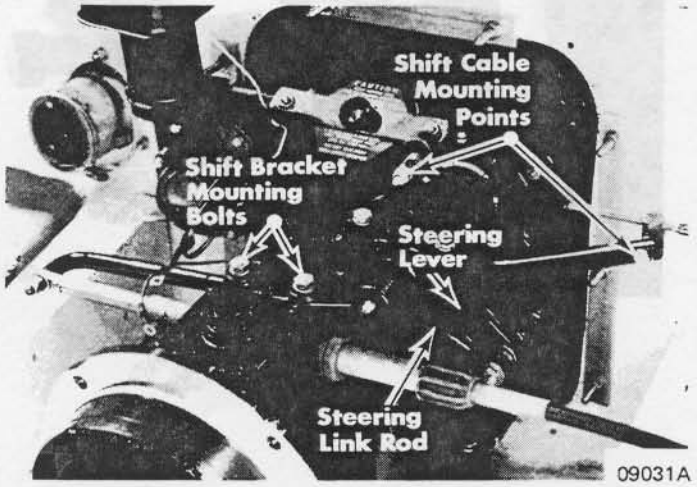


Figure 12. Cables Mounted from Port (Left) Side

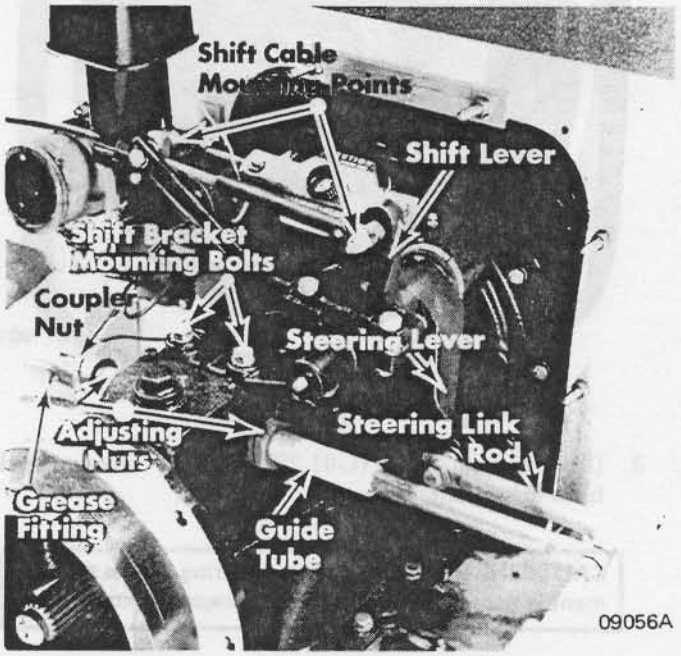


Figure 13. Cables Mounted from Starboard (Right) Side

IMPELLER and DRIVE SHAFT HOUSING COMPONENT REMOVAL/CLEANING and INSPECTION/DISASSEMBLY

IMPELLER and WEAR RING

REMOVAL

NOTE: It is recommended that impeller be removed with impeller housing and engine installed in boat to allow engine to hold drive shaft from turning while removing impeller retaining nut.

1. Remove stator housing assembly. Refer to "Stator Housing Removal" (use "Index").
2. Remove impeller retainer nut. (Figure 1)

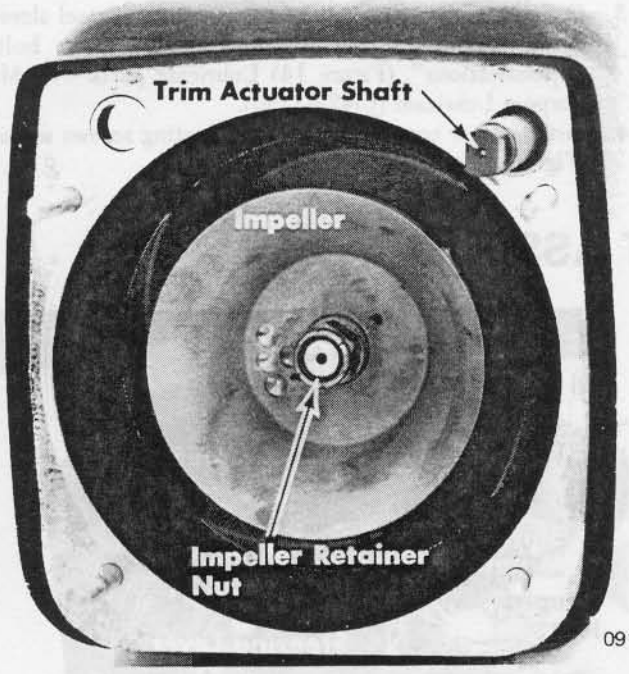


Figure 1. Impeller and Impeller Nut

3. Use Universal Puller (C-91-25733A2) to remove impeller from drive shaft. (Figure 2)

CAUTION: DO NOT remove wear ring, unless replacement is necessary. Ring will be damaged in removal.

4. Use Wear Ring Puller Tool (part of Tool Kit C-91-73058) to remove wear ring and liner. (Figure 3)

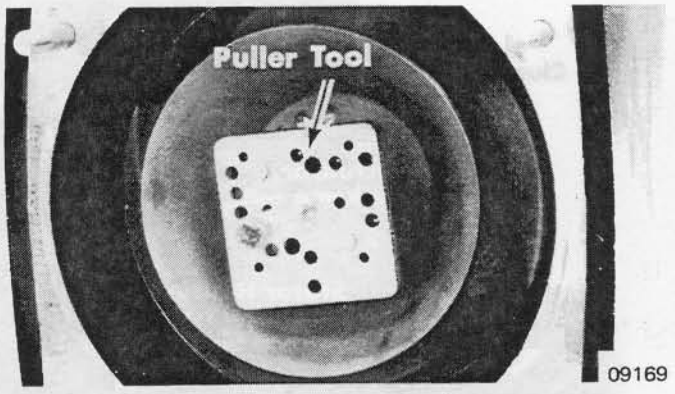


Figure 2. Removing Impeller

CLEANING and INSPECTION

NOTE: Impeller can be visually inspected without removal by removing inspection cover (located on top of drive shaft housing).

1. Check impeller for nicks or bent condition caused by foreign material entering impeller. Pay particular attention to area of impeller near wear ring and edges at water passages.
2. Inspect wear ring for nicks and wear and replace if necessary.

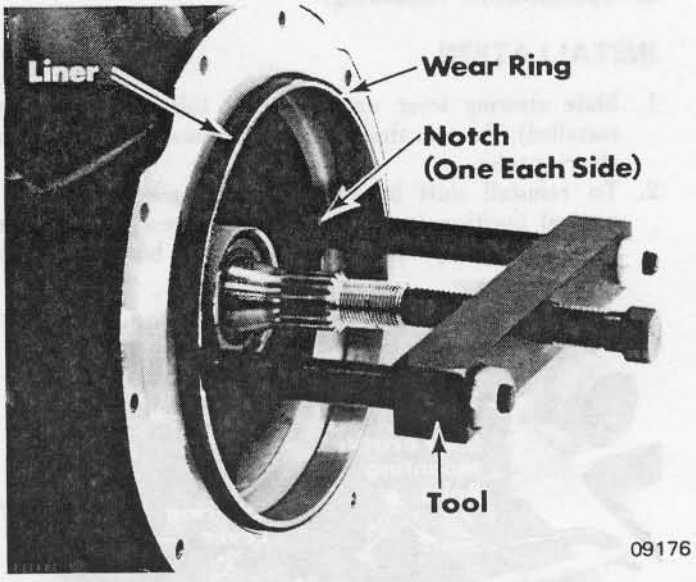


Figure 3. Removing Wear Ring and Liner

IMPELLER HOUSING

REMOVAL

Remove 10 bolts and lockwashers and remove impeller housing. (Figure 4)

CLEANING and INSPECTION

1. Inspect housing painted surface and remove any corrosion. Use primer paint on bare metal surfaces before applying finish coat.

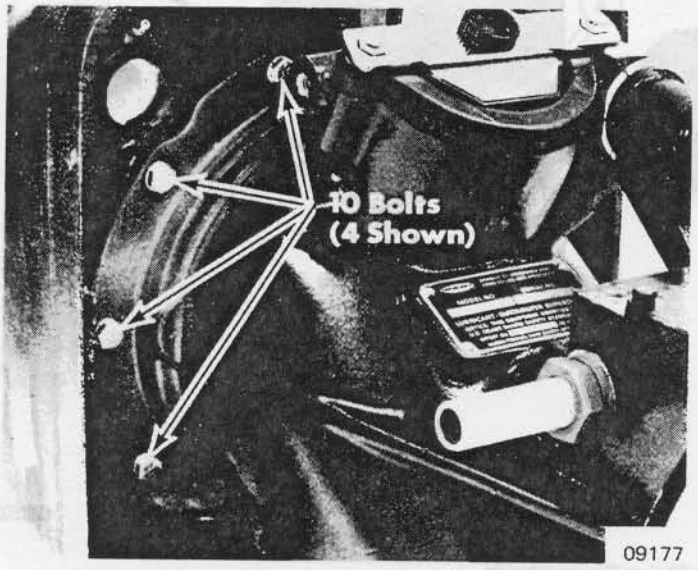


Figure 4. Removing Impeller Housing

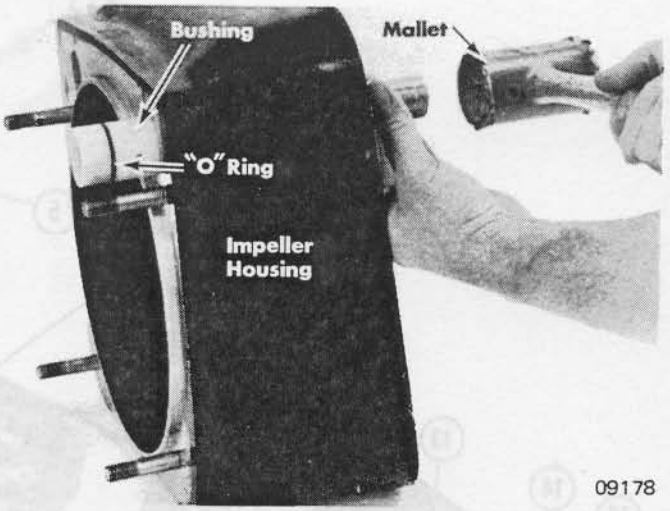


Figure 5. Removing Trim Actuator Bushing

2. Check trim actuator shaft bushing for wear. If leakage occurred in bushing area, replace bushing "O" rings.
3. Replace stator housing to impeller housing studs, if threads are damaged or corroded.

DISASSEMBLY

1. Use proper adaptor to drive trim actuator shaft bushing out of impeller housing. (Figure 5)
2. Remove stator housing to impeller housing studs, if necessary.

POWER TRIM ACTUATOR

REMOVAL

1. Disconnect trim motor electrical wiring.
2. Remove cotter pin and clevis pin from trim actuator linkage. (Figure 1)
3. Remove 2 mounting bolts and lift out actuator. (Figure 1)

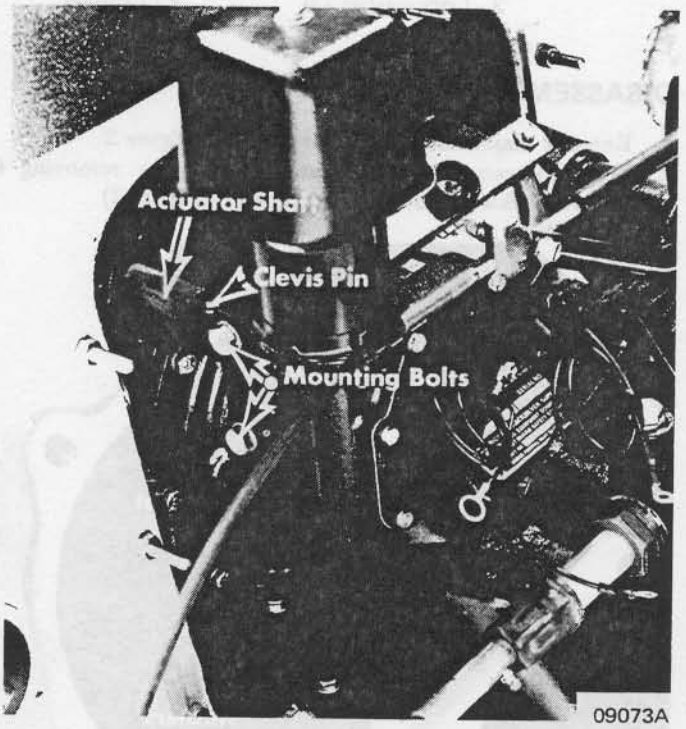


Figure 1. Removing Trim Actuator

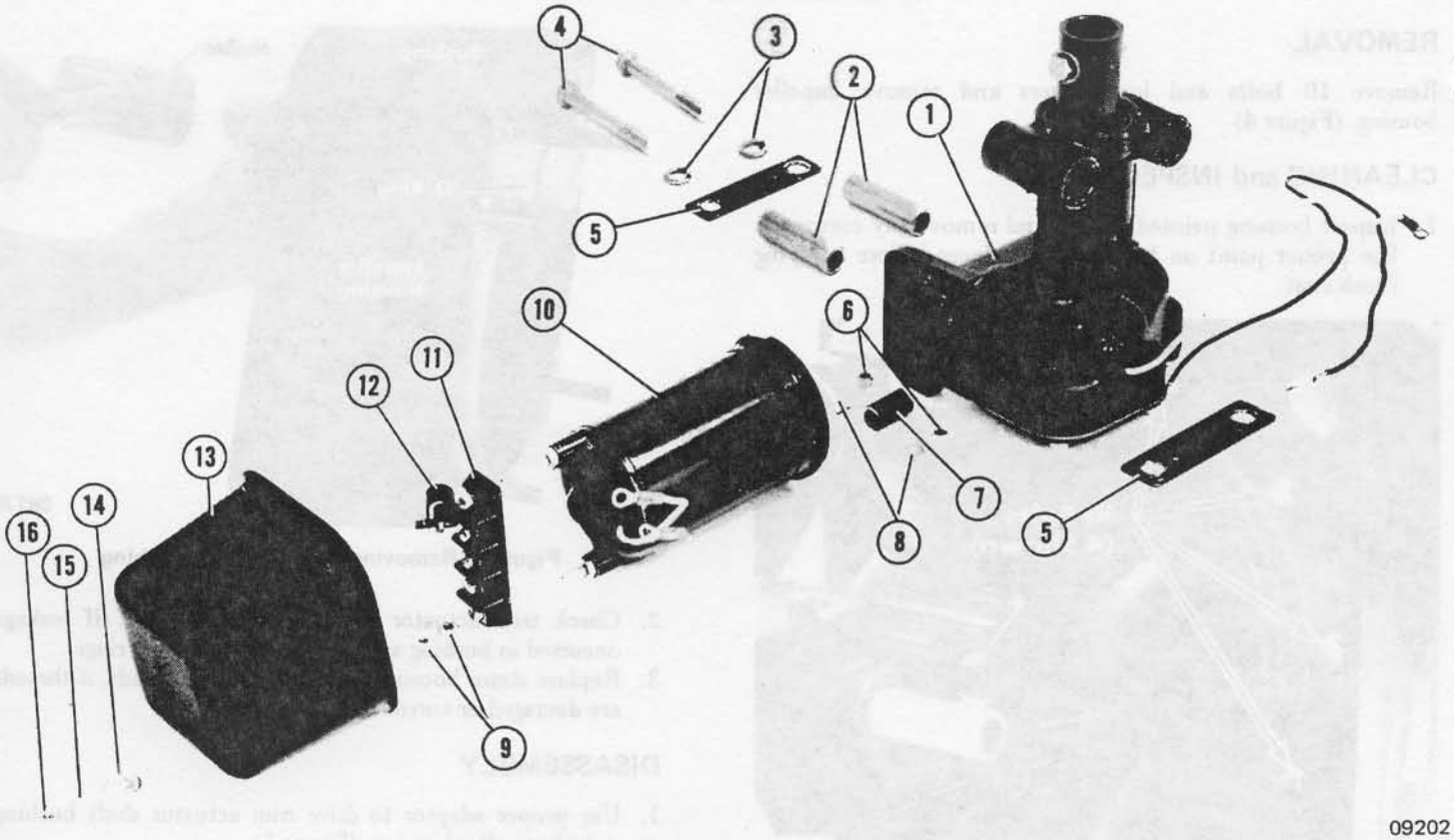


Figure 2. Trim Actuator Major Components

Parts Identification for Figure 2

1 - Trim Actuator	5 - Plate (2)	9 - Nut (2)	13 - Cover
2 - Sleeve (2)	6 - Nut (2)	10 - Trim Motor	14 - Washer
3 - Lockwasher (2)	7 - Coupler	11 - Terminal Block	15 - Lockwasher
4 - Bolt (2)	8 - Washer (2)	12 - Clamp	16 - Nut

DISASSEMBLY

1. Remove major components as shown in Figure 2.
2. Start disassembly of actuator housing by removing 6 screws, lockwashers, cover and gasket. (Figure 2)

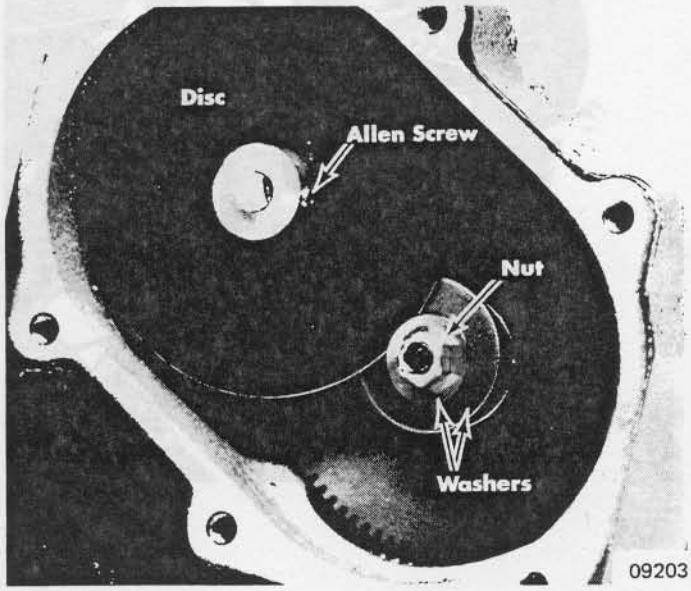


Figure 3. Removing Disc and Disc Drive Assembly

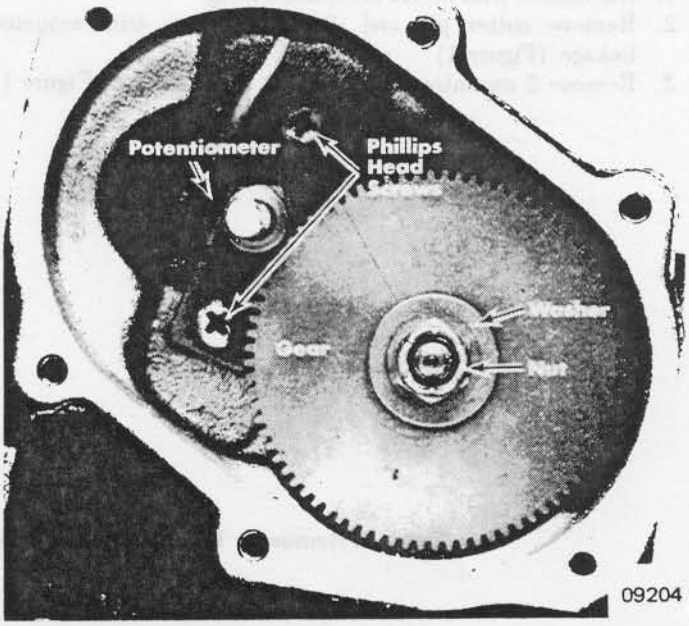


Figure 4. Removing Potentiometer, Gear and Actuator Shaft

3. Loosen allen screw on disc and remove nut (holding spring loaded washer) from end of actuator shaft. (Figure 3) Remove 2 washers, nut and disc.

4. Remove 2 phillips head screws and lift out potentiometer assembly. (Figure 4) Potentiometer can be disassembled by removing special nut. (Figure 5)
5. Remove gear retaining nut from actuator shaft. (Figure 4) Gear, bearing assembly and actuator shaft may be removed. (Figure 5) Pry out oil seal.
6. Pry out welch plug and use a snap ring pliers to remove retaining ring. Ball bearing, wave washer, worm gear, second wave washer, second ball bearing and oil seal may be removed. (Figure 5)

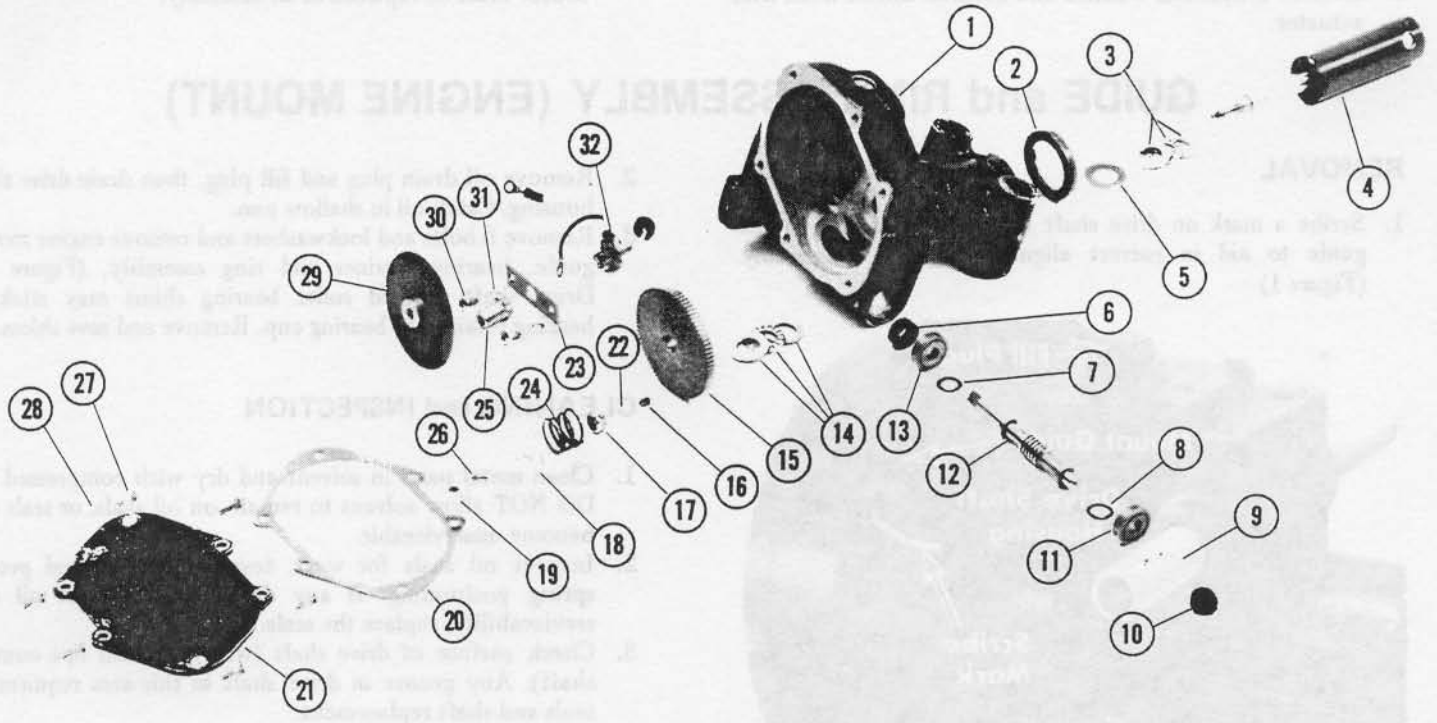


Figure 5. Trim Actuator Parts Identification

Parts Identification for Figure 5

1 - Actuator Housing	9 - Retaining Ring	17 - Nut	25 - Special Nut
2 - Oil Seal	10 - Welch Plug	18 - Washer	26 - Washer
3 - Thrust Bearing Assembly	11 - Ball Bearing	19 - Nut	27 - Screw (6)
4 - Actuator Shaft	12 - Worm Gear	20 - Gasket	28 - Lockwasher (6)
5 - Belleville Washer	13 - Ball Bearing	21 - Cover	29 - Disc
6 - Seal	14 - Thrust Bearing Assembly	22 - Washer	30 - Screw (2)
7 - Wave Washer	15 - Gear	23 - Retainer	31 - Lockwasher (2)
8 - Wave Washer	16 - Key	24 - Spring	32 - Potentiometer

CLEANING and INSPECTION

1. Clean all metal parts in solvent and dry with compressed air.
2. Inspect gears for pitting, chipped or broken teeth and excessive or uneven wear.
3. Apply a very light coat of oil to ball bearings. Rotate bearing and check for rough spots. Replace bearing, if rough.
4. Check roller bearing for utility by inspecting bearing contact surface of bearing race. Pitting, grooves, scoring and uneven wear warrant bearing replacement.
5. Inspect oil seals for wear, tears, roughness and proper spring positioning. If there is any doubt about oil seal serviceability, replace oil seals.
6. Check disc and its drive washers for excessive wear.
7. To test trim potentiometer, connect ohm meter leads to white and black wires. While turning potentiometer shaft, ohm meter should indicate from 0-to-100 ohms with no irregular readings or loss of continuity throughout.

   NOTE: Potentiometer may be tested without disassembly of trim actuator by connecting ohm meter leads to purple/white wire and actuator housing. Operate trim thru its cycle to turn potentiometer shaft. Ohm readings are the same as preceding step.

POWER TRIM MOTOR

REMOVAL

1. Disconnect trim motor electrical wiring.
2. Remove 2 nuts and washers and lift trim motor from trim actuator.

NOTE: Replacement parts for motor are not available. Motor must be replaced as an assembly.

GUIDE and RING ASSEMBLY (ENGINE MOUNT)

REMOVAL

1. Scribe a mark on drive shaft housing and engine mount guide to aid in correct alignment during reassembly. (Figure 1)

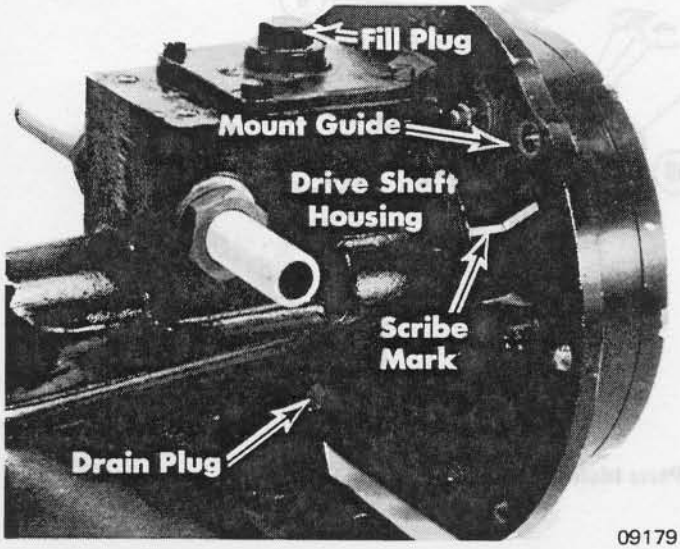


Figure 1. Oil Drain Plug and Scribe Mark on Housings

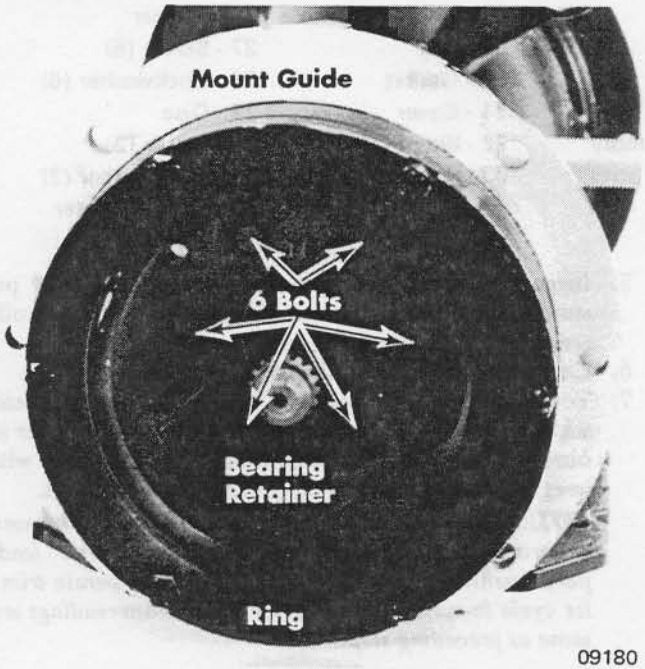


Figure 2. Removing Bearing Retainer, Mount Guide and Ring Assembly

2. Remove oil drain plug and fill plug, then drain drive shaft housing. Catch oil in shallow pan.
3. Remove 6 bolts and lockwashers and remove engine mount guide, bearing retainer and ring assembly. (Figure 2) Drive shaft tapered roller bearing shims may stick to bearing retainer or bearing cup. Remove and save shims.

CLEANING and INSPECTION

1. Clean metal parts in solvent and dry with compressed air. DO NOT allow solvent to remain on oil seals, or seals will become unserviceable.
2. Inspect oil seals for wear, tears, roughness and proper spring positioning. If any doubt exists about oil seal serviceability, replace the seals.
3. Check surface of drive shaft (where oil seal lips contact shaft). Any groove in drive shaft in this area requires oil seals and shaft replacement.
4. If oil leakage is evident between bearing retainer and mount guide, replace "O" rings. (Figure 3)

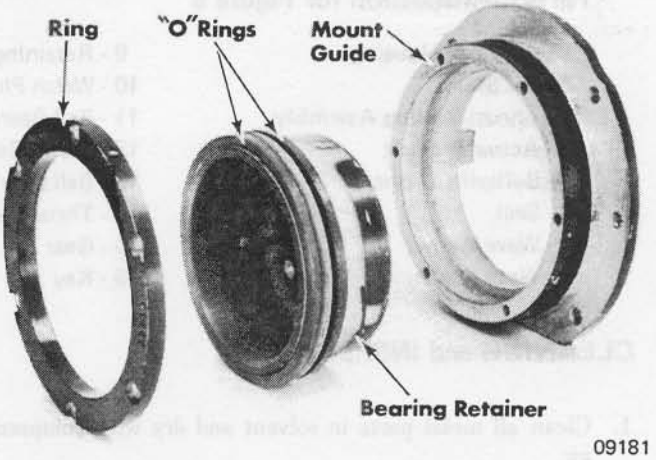


Figure 3. Disassembling Bearing Retainer, Mount Guide and Ring

DISASSEMBLY

1. Remove 6 nuts, bolts and washers, then lift ring and bearing retainer from mount guide. (Figure 3)
2. Remove 2 "O" rings from bearing retainer.
3. Remove 2 oil seals from bearing retainer. Oil seals may be removed without component disassembly.

DRIVE SHAFT ASSEMBLY

REMOVAL

1. Install impeller retaining nut on end of drive shaft to protect drive shaft threads. Use a mallet on end of drive shaft to remove tapered roller bearing cup. Catch bearing cup with other hand. (Figure 4)
2. Remove impeller nut from shaft and pull drive shaft out of housing. Drive shaft thrust bearing assembly may remain in housing or on shaft. Remove thrust bearing. Tie bearing assembly together with a string to keep bearing races from being interchanged.

CLEANING and INSPECTION

1. Clean in solvent and dry with compressed air.
2. Inspect area of drive shaft where roller bearing rides. Pitting, grooves, scoring, uneven wear, discoloration from overheating and/or embedded foreign metal particles require replacement of drive shaft and roller bearing.

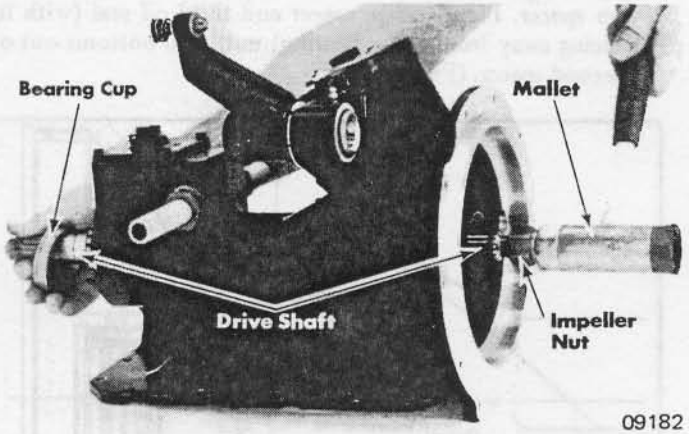


Figure 4. Removing Bearing Cup and Drive Shaft

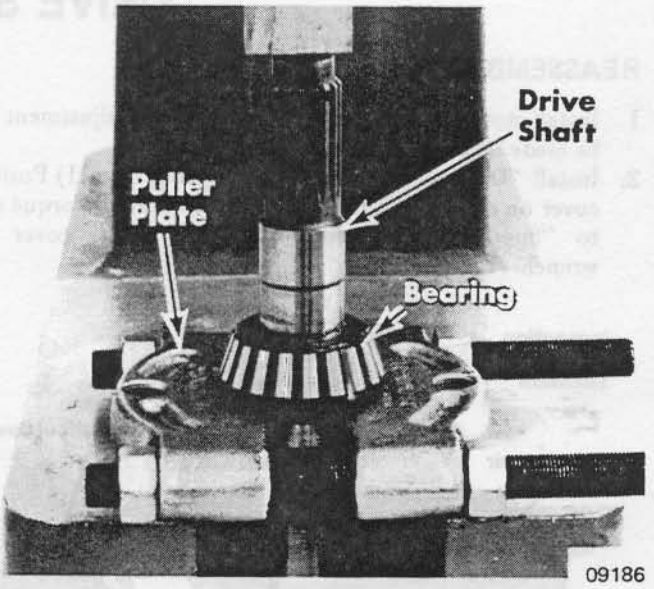


Figure 5. Pressing Drive Shaft from Tapered Roller Bearing

3. Check drive shaft tapered roller bearing by inspecting bearing cup. Replace bearing and bearing cup if cup is pitted, grooved, scored, worn uneven, discolored from overheating or has foreign metal particles embeded in cup.
4. Inspect drive shaft splines (both ends) for wear.
5. If impeller was damaged from foreign object in impeller housing, or if jet drive had a vibration, check drive shaft for straightness.

DISASSEMBLY

Press drive shaft from tapered roller bearing with Universal Puller Plate (C-91-37241) and arbor press. (Figure 5)

DRIVE SHAFT HOUSING ASSEMBLY

DISASSEMBLY

1. Remove 3 oil seals from drive shaft cavity. (Figure 6)
2. Remove drive shaft roller bearing. (Figure 6)
3. Remove snap ring from steering lever assembly and remove lever and 2 nyliners. (Figure 6)
4. Remove steering cable tube.
5. Remove inspection cover and "O" Ring.
6. Remove 4 screws and lockwashers and lift off oil reservoir cover and gasket.

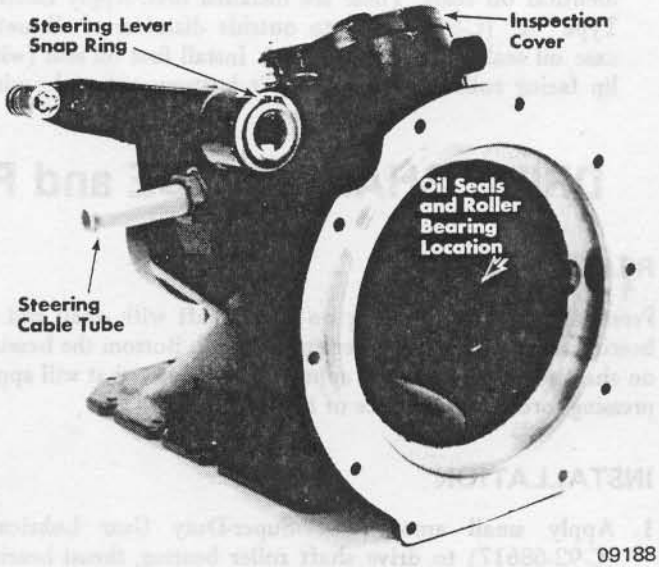


Figure 6. Drive Shaft Housing Assembly

DRIVE SHAFT & IMPELLER HOUSING REASSEMBLY/INSTALLATION

DRIVE SHAFT HOUSING

REASSEMBLY

1. Install steering cable tube. (Figure 1) Tube adjustment will be made when installing steering cable.
2. Install "O" ring on inspection cover. (Figure 1) Position cover on drive shaft housing and install nuts. Torque nuts to "Specifications", following, and install cover nut wrench. (Figure 2)

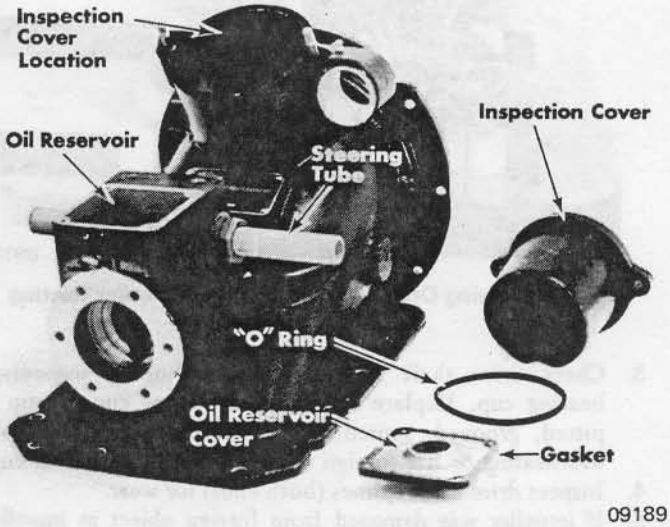


Figure 1. Drive Shaft Housing Reassembly

3. Using a new gasket, install oil reservoir cover with 4 bolts and lockwashers. Torque bolts to "Specifications". (Figure 1)
4. Lubricate nyliners and steering lever with Multipurpose Lubricant (C-92-63250). Install nyliners, steering lever and retaining snap ring. (Figure 2)
5. Press drive shaft roller bearing into housing (numbered end out) until bearing bottoms on shoulder in housing. Use an appropriate adaptor that will apply pressure on bearing case. DO NOT press on end of rollers. (Figure 3)
6. To install drive shaft, 3 oil seals and 2 spacers, find the 2 identical oil seals. These are installed first. Apply Loctite Type "A" (C-92-32609) to outside diameter of all metal case oil seals before installation. Install first oil seal (with lip facing roller bearing) until it bottoms-out on housing

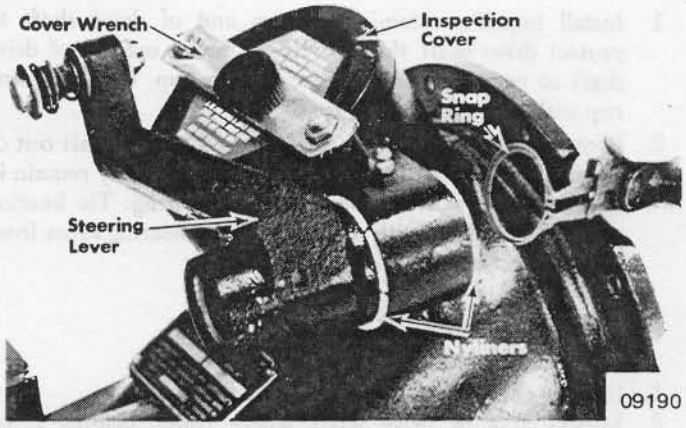


Figure 2. Installing Steering Lever

shoulder. Install one spacer and second oil seal (with seal lip facing away from roller bearing) until seal bottoms-out on spacer. Install other spacer and third oil seal (with lip facing away from roller bearing) until seal bottoms-out on second spacer. (Figure 3)

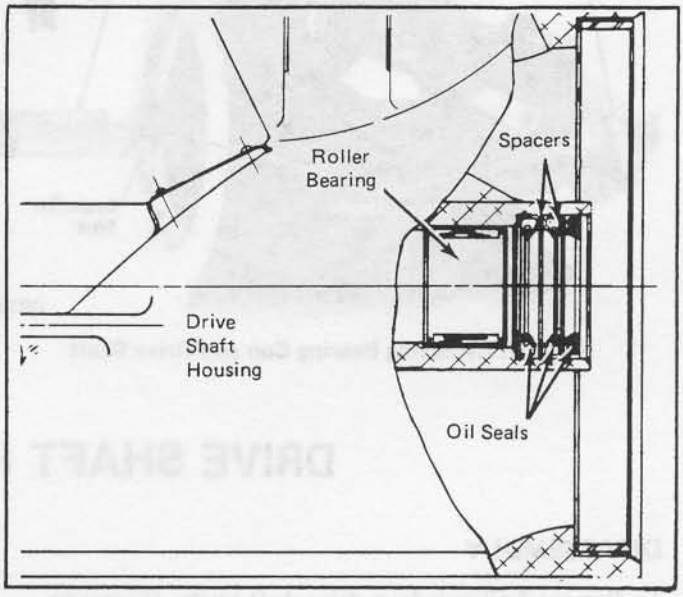


Figure 3. Roller Bearing and Oil Seals Positions

DRIVE SHAFT, GUIDE and RING ASSEMBLY (ENGINE MOUNT)

REASSEMBLY

Press tapered roller bearing on drive shaft with small end of bearing facing engine coupler end of shaft. Bottom the bearing on shaft's shoulder. Use an appropriate adaptor that will apply pressing force to inside race of bearing only.

INSTALLATION

1. Apply small amount of Super-Duty Gear Lubricant (C-92-68617) to drive shaft roller bearing, thrust bearing and tapered roller bearing. Apply Multipurpose Lubricant (C-92-63250) to lip of oil seals.

CAUTION: DO NOT interchange thrust bearing races.

2. Place thrust bearing on drive shaft in order removed and insert drive shaft assembly into housing. (Figure 4)
3. Lightly tap tapered roller bearing race in position with a mallet. (Figure 5)

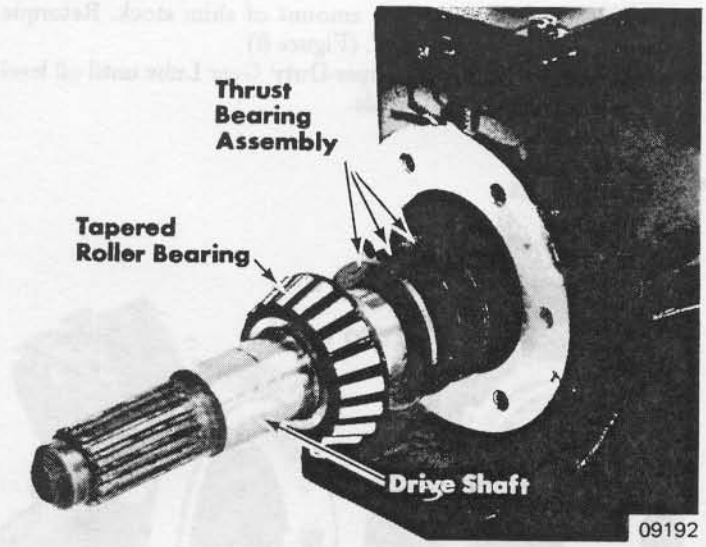


Figure 4. Installing Drive Shaft

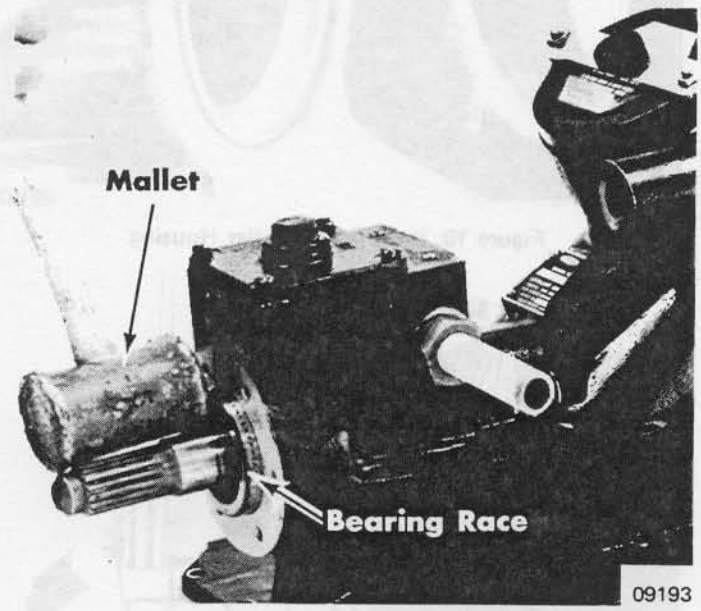


Figure 5. Installing Drive Shaft Bearing Cup

4. Reassemble guide and ring assembly (engine mount) as follows:
   a. Install first oil seal in bearing retainer (with spring-loaded lip facing shoulder of housing) until seal bottoms-out on housing shoulder. Use Loctite Type "A" (C-92-32609) on metal outside diameter of both oil seals. Install second oil seal (with plain lip facing away from shoulder) until seal is flush with housing.
   b. Place 2 "O" rings on bearing retainer. (Figure 6) Lubricate "O" rings with Multipurpose Lubricant and reassemble parts in order shown in Figure 6.
   c. Install 6 bolts from forward (ring) end of assembly with nuts and washers. Align scribe mark (made during disassembly) and torque nuts to "Specifications", following. (Figure 7)

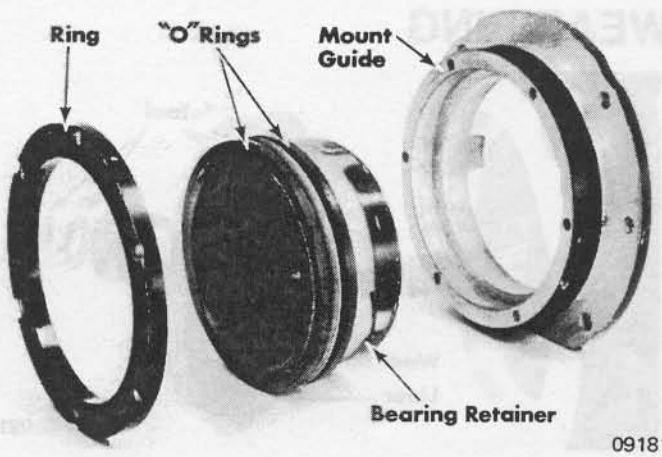


Figure 6. Engine Mount Guide Assembly

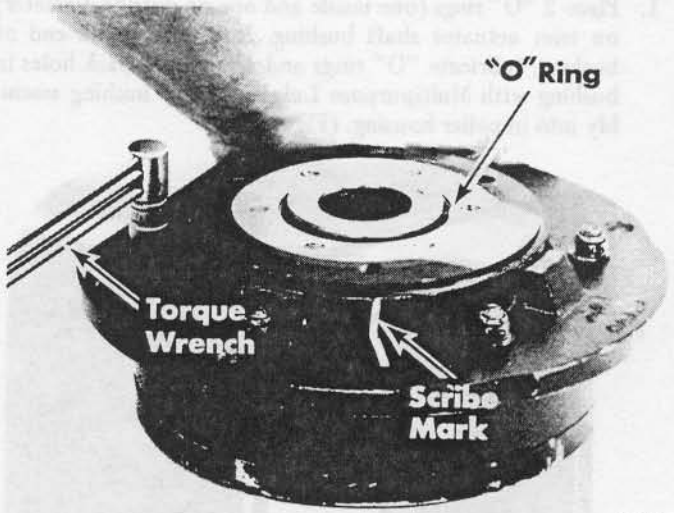


Figure 7. Torquing Engine Mount Assembly

   d. Place "O" ring in groove on bearing retainer. Use a small amount of Glue (C-92-25234) to hold "O" ring in place during housing installation.
5. Lubricate oil seal lips with Multipurpose Lubricant and position shims removed, plus .030" additional, in drive shaft housing.
6. Position engine mount assembly onto drive shaft housing with portion marked "top" toward top. (Figure 8) Be careful that shims do not fall out-of-place.

Figure 8. Installing Engine Mount Assembly

7. Install 6 bolts and lockwashers and torque bolts evenly to "Specifications".
8. Use a feeler gauge to check gap (at 3 different locations) between housing. (Figure 8) Take average reading, plus .004", and remove that amount of shim stock. Retorque bolts to "Specifications". (Figure 8)
9. Fill oil reservoir with Super-Duty Gear Lube until oil level reaches bottom of fill hole.

IMPELLER HOUSING

REASSEMBLY

1. Place 2 "O" rings (one inside and one on outside diameter) on trim actuator shaft bushing. Insert scraper in end of bushing, lubricate "O" rings and scraper and pack holes in bushing with Multipurpose Lubricant. Tap bushing assembly into impeller housing. (Figure 9)

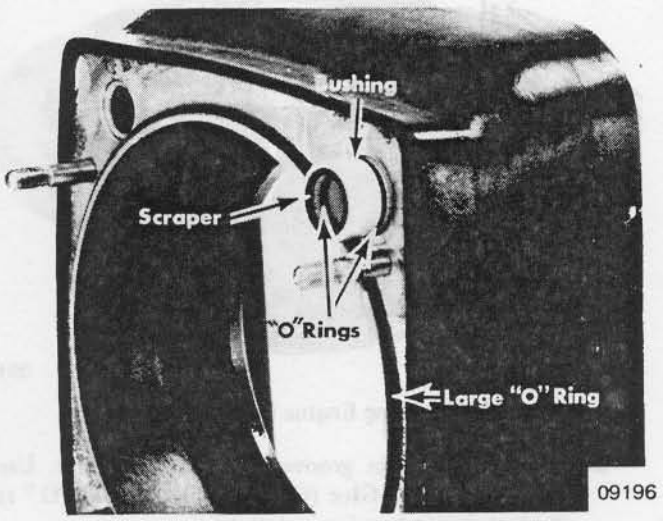


Figure 9. Impeller Housing

2. Place nylon washer, "O" ring and second nylon washer on steering tube. Be careful not to cut "O" ring on steering tube slot. Lubricate them with Multipurpose Lubricant.
3. Position large "O" ring on shoulder around impeller cavity. (Figure 9)

INSTALLATION

1. Place "O" ring on drive shaft housing (Figure 10) and install impeller housing onto drive shaft housing.
2. Install 10 bolts with lockwashers and torque bolts evenly to "Specifications". (Figure 11)

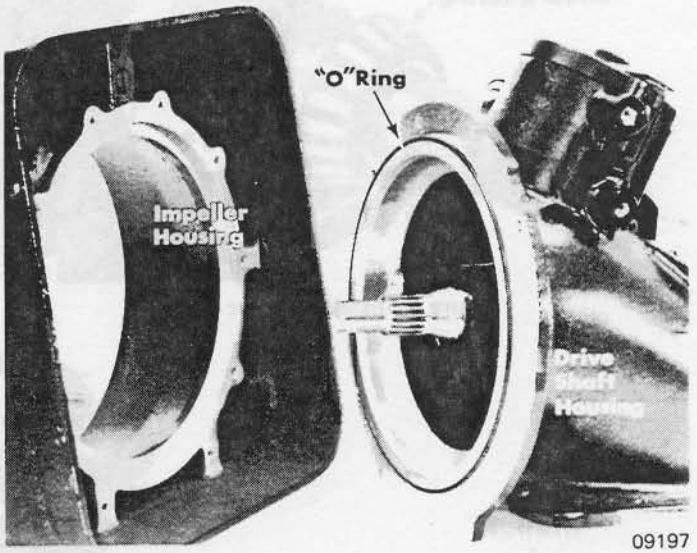


Figure 10. Installing Impeller Housing

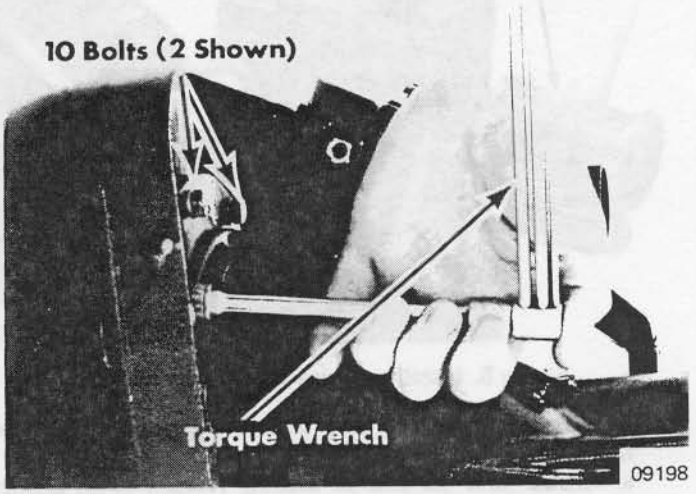


Figure 11. Torquing Impeller Housing Bolts

IMPELLER and WEAR RING

INSTALLATION

1. Position wear ring and liner on installing tool. (Figure 12) Lubricate outside diameter of liner with a liquid soap for an installation lubrication. Thread center adaptor of tool on drive shaft. (Figure 12) Place large (disc) part of tool (with wear ring and liner) over tool adaptor and install nut and washer on adaptor. (Figure 13) Tighten nut until wear ring bottoms on shoulder in drive shaft housing.

NOTE: Wear ring may be installed with impeller housing installed. Impeller housing was removed for photo purposes.

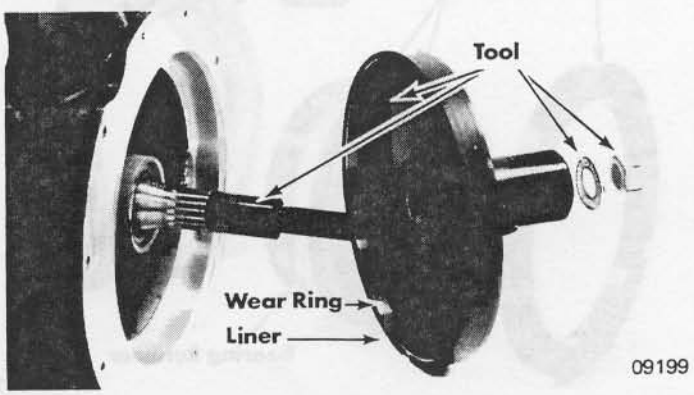


Figure 12. Wear Ring Tool Installation

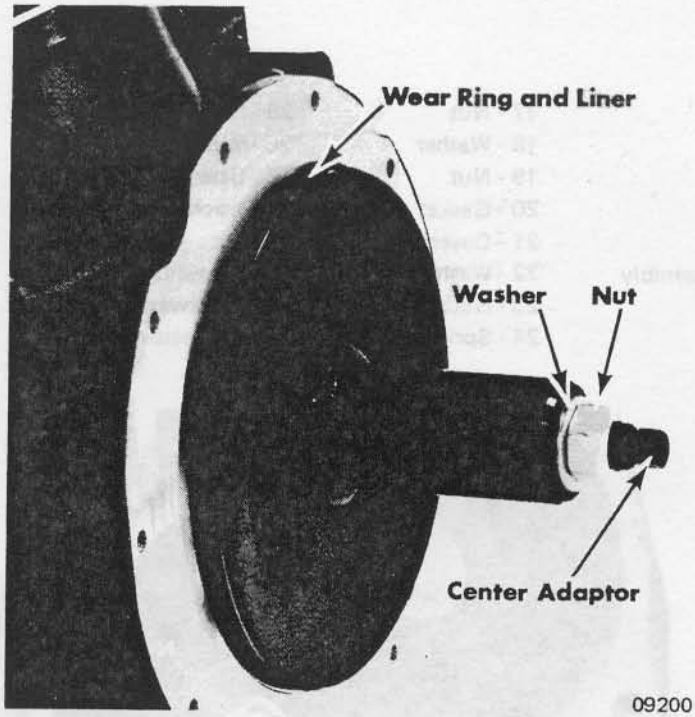


Figure 13. Installing Wear Ring and Liner

NOTE: It is recommended that impeller be installed with drive shaft housing and engine installed in boat (to allow engine to hold drive shaft from turning) while torquing impeller retaining nut.

2. Install impeller, washer and retaining nut. (Figure 14) Torque nut to "Specifications", following.

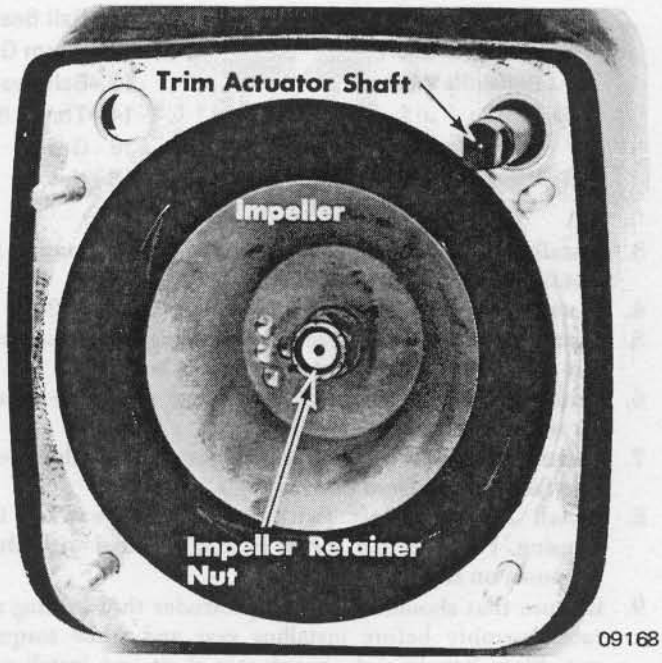


Figure 14. Installing Impeller

POWER TRIM ACTUATOR

REASSEMBLY

1. Install small worm gear shaft oil seal in housing cavity with lip facing actuator motor. (Figure 15) Lubricate lip of seal with Multipurpose Lubricant (C-92-63250).

2. Pack worm gear ball bearings with Multipurpose and install 2 wave washers and 2 ball bearings on worm gear shaft in order shown in Figure 15.

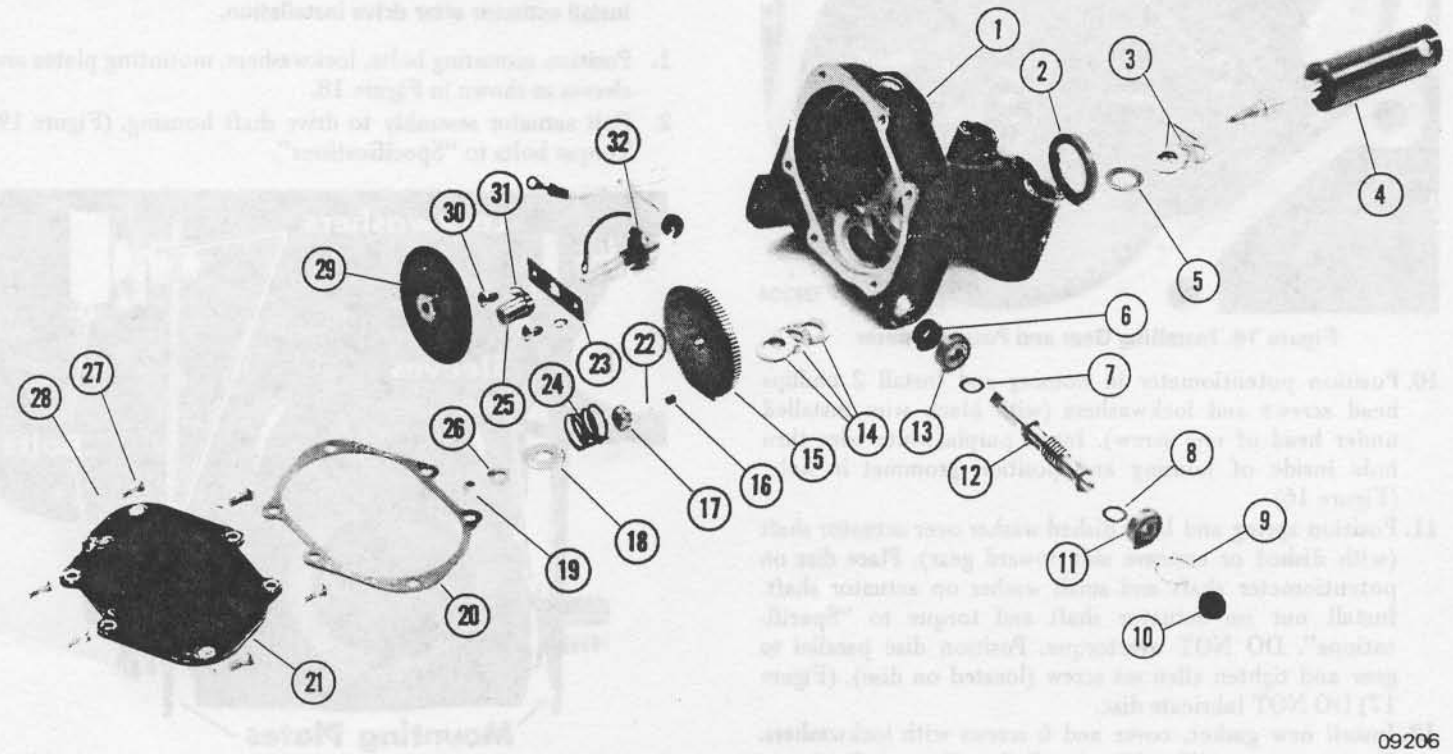


Figure 15. Trim Actuator Parts Identification

Parts Identification for Figure 15

1 - Actuator Housing
2 - Oil Seal
3 - Thrust Bearing Assembly
4 - Actuator Shaft
5 - Belleville Washer
6 - Seal
7 - Wave Washer
8 - Wave Washer
9 - Retaining Ring
10 - Welch Plug
11 - Ball Bearing
12 - Worm Gear
13 - Ball Bearing
14 - Thrust Bearing Assembly
15 - Gear
16 - Key
17 - Nut
18 - Washer
19 - Nut
20 - Gasket
21 - Cover
22 - Washer
23 - Retainer
24 - Spring
25 - Special Nut
26 - Washer
27 - Screw (6)
28 - Lockwasher (6)
29 - Disc
30 - Screw (2)
31 - Lockwasher (2)
32 - Potentiometer

3. Install worm gear and bearing assembly into housing and install retaining ring in groove.
4. Install welch plug, using Loctite No. 35 (C-92-59328).
5. Install actuator shaft oil seal into housing until it bottoms-out on shoulder (with lip facing toward housing).
6. Pack thrust bearing with Multipurpose and place bearing on actuator shaft. (Figure 15)
7. Position belleville washer on actuator shaft (with concave side facing away from bearing).
8. Install actuator shaft (with bearing and washer) into housing. Place second thrust bearing (packed with Multipurpose) on shaft. (Figure 15)
9. Be sure that shoulder on shaft protrudes thru bearing and race assembly before installing gear and while torquing nut. Place key in slot on actuator shaft and install gear. Install washer and nut and torque to "Specifications", following. (Figure 16) Lubricate worm gear and driven gear teeth with Multipurpose.

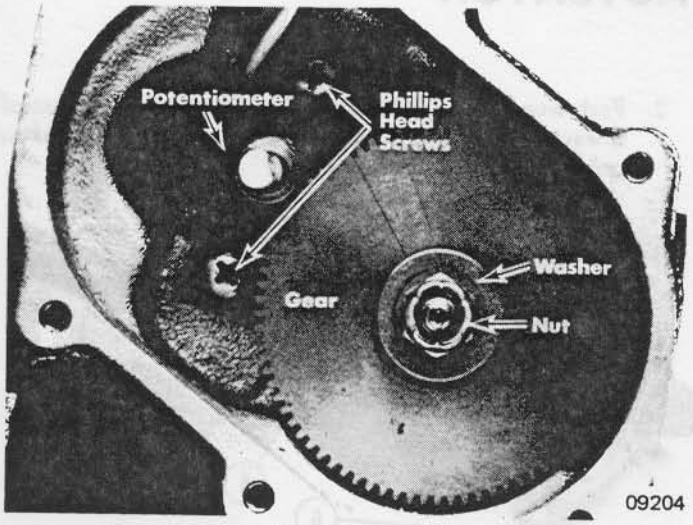


Figure 16. Installing Gear and Potentiometer

10. Position potentiometer in housing and install 2 phillips head screws and lockwashers (with black wire installed under head of one screw). Insert purple/white wire thru hole inside of housing and position grommet in hole. (Figure 16)
11. Position spring and large dished washer over actuator shaft (with dished or concave side toward gear). Place disc on potentiometer shaft and small washer on actuator shaft. Install nut on actuator shaft and torque to "Specifications". DO NOT overtorque. Position disc parallel to gear and tighten allen set screw (located on disc). (Figure 17) DO NOT lubricate disc.
12. Install new gasket, cover and 6 screws with lockwashers. Torque nut to "Specifications". Install ground wire to cover screw from which it was removed.

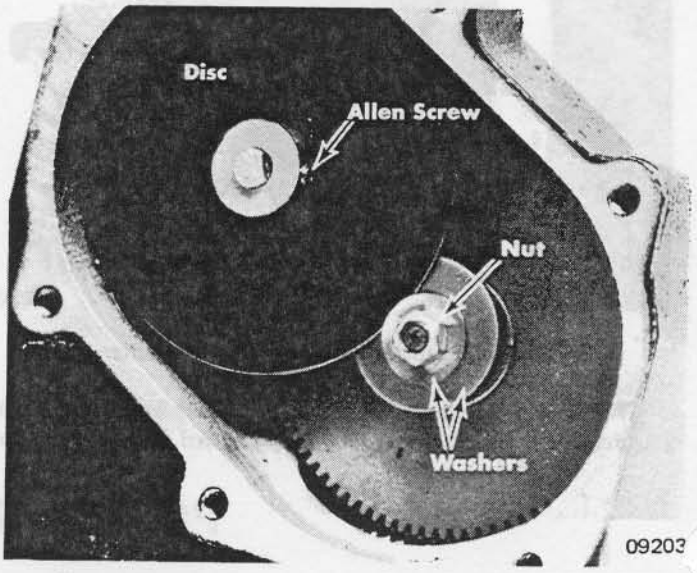


Figure 17. Installing Disc and Disc Drive Assembly

INSTALLATION

IMPORTANT: Trim actuator must be removed for drive shaft housing installation in boat. If jet drive is removed, install actuator after drive installation.

1. Position mounting bolts, lockwashers, mounting plates and sleeves as shown in Figure 18.
2. Bolt actuator assembly to drive shaft housing. (Figure 19) Torque bolts to "Specifications".

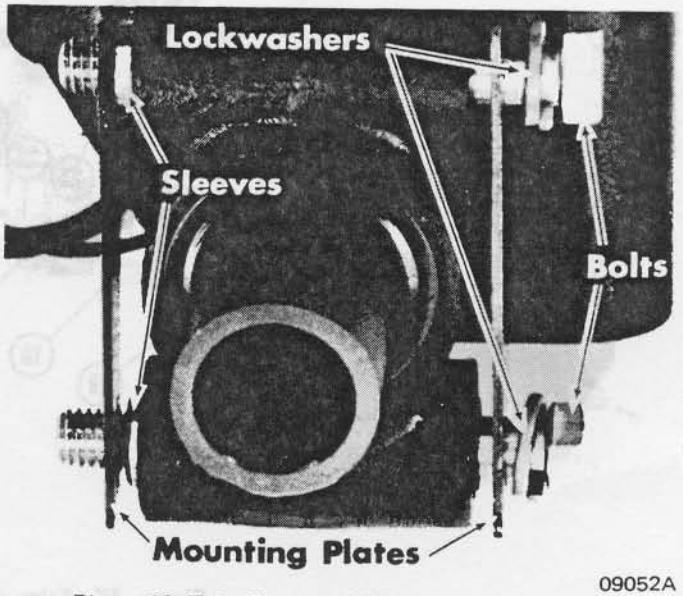


Figure 18. Trim Actuator Mounting Sequence

3. It may be necessary to turn trim motor actuator shaft to align holes so that clevis pin and cotter pin can be installed. Spread end of cotter pin.
4. Connect trim harness matching-color wires. Connect black wire from actuator cover mounting screw to starboard engine head.

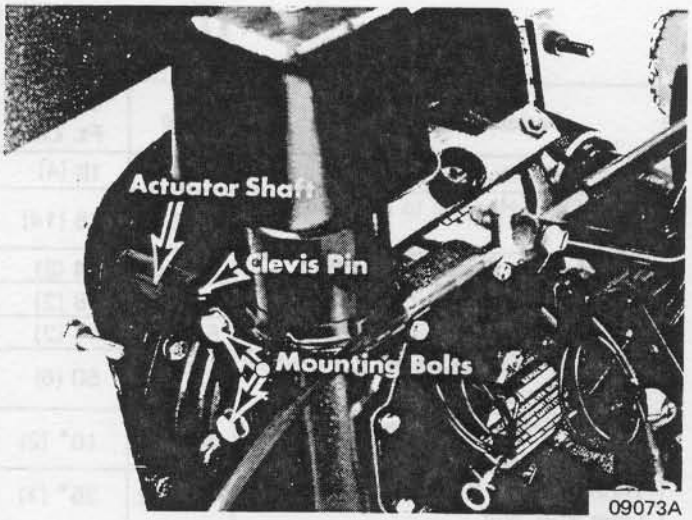


Figure 19. Mounting Trim Actuator

TORQUE SPECIFICATIONS

Fastener Location	Size	Torque Ft. Lbs.
Grate to Intake Housing, Nut	5/16	18 (4)
Drive Shaft Housing to Inlet Housing, Bolts	5/16	18 (14)
Transom Seal Retainer Stud, Nut	5/16	14 (8)
Transom Seal Retainer, Lag Bolts	5/16	18 (2)
Cover to Stator Housing, Bolts	5/16	14 (2)
Drive Unit Engine Mount to Flywheel Housing Stud, Nut	7/16	50 (6)
Neutral Start Safety Switch to Shift Bracket, Screw	#6	10* (2)
Throttle Cable End Guide to Throttle Lever Bolt, Nut	#10-32	25* (1)
Throttle Cable Brass Barrel to Anchor Stud, Nut	¼-28	90* (1)
Stator Housing Cover Pads to Stator Housing Screw, Nut	#10	24* (2)
Stator Housing Mounting Lugs Retaining Screw, Nut	#10	24* (2)
Rudder Mount to Stator Housing Bolt, Nut	¼	80* (4)
Stator Housing Assembly to Impeller Housing Stud, Nut	½	50 (4)
Impeller Inspection Cover to Drive Shaft Housing Stud, Nut	5/16	14 (2)
Oil Reservoir Cover to Drive Shaft Housing, Bolts	¼	80* (4)
Retaining Ring to Mount Guide Bolt, Nut	5/16	18 (6)
Mount Guide Assembly to Drive Shaft Housing, Bolts	5/16	18 (6)
Drive Shaft Housing to Impeller Housing, Bolts	5/16	18 (10)
Impeller to Drive Shaft, Nut	7/8	90 (1)
Shift Bracket to Drive Shaft Housing, Bolts	3/8	30 (2)
Shift Lever to Neutral Start Cam, Nut	#10	24* (1)
Shift Cable to Shift Lever Stud, Nut	¼	50* (1)
Shift Cable to Cable Support Arm Stud, Nut	¼	50* (1)

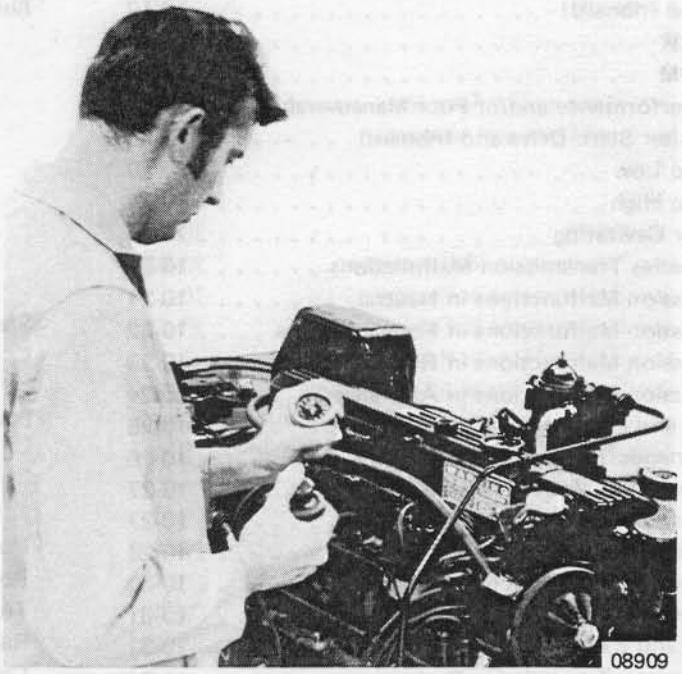
Fastener Location	Size	Torque Ft. Lbs.
Shift Shaft End to Bushing Block Retaining, Nut	5/16	14 (1)
Shift Shaft Support Bracket to Bushing Block, Nut	5/16	14 (1)
Shift Shaft Support Bracket to Gimbal Ring Bolt, Nut	5/16	18 (2)
Shift Link Rod to Shift Shaft Weldment, Nut	5/16	14 (1)
Shift Link Rod to Reverse Gate, Nut	5/16	14 (1)
Shift Cable Support Arm to Shift Lever Bracket Bolts, Nut	5/16	18 (2)
Shift Lever Retainer to Shift Bracket, Bolt	5/16	14 (1)
Steering Cable Coupler, Nut	7/8	40 (1)
Steering Mounting Tube Adjusting, Nut	7/8	40 (1)
Steering Link Rod to Steering Lever, Nut	5/16	18■ ▲(1)
Steering Link Rod to Cable End, Nut	3/8	25* +■ (1)
Steering Linkage to Steering Deflector Bolt, Nut	5/16	18▲■ (1)
Steering Linkage to Steering Tube (Shaft) Bolt, Nut	5/16	18▲■ (1)
Steering Tube (Shaft) Clamp Screw, Nut	#10	24* (1)
Trim Actuator to Drive Shaft Housing, Bolt	3/8	30 (2)
Trim Linkage to Gimbal Ring, Nut	3/8	30■ (1)
Trim Actuator Shaft Coupler Bolt, Nut (Outside Boat)	3/8	21 (1)
Trim Actuator Driven Gear to Actuator Shaft, Nut	3/8	140* (1)
Trim Potentiometer to Actuator Housing, Screw	#10	32* (2)
Trim Potentiometer Disc to Potentiometer Shaft, Set Screw	#8	16* (1)
Trim Potentiometer Disc to Actuator Shaft, Nut	#10	32* (1)
Trim Actuator Cover to Actuator Housing	#10	24* (6)

(1), (2), (3), Etc = Quantity * *In. Lbs.* + *Back Off ¼-Turn* ■ *Install Cotter Pin*

▲ *If Cotter Pin Does Not Line Up with Cross-Drilled Hole, Apply Higher Torque until Alignment Occurs.*

Metric Scale: 1 Ft. Lb. = .14mkg; 1 In. Lb. = 1.15kg-cm.

TROUBLE-SHOOTING MERCRUISER Section 10



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SECTION 10 - TROUBLESHOOTING

A BRUNSWICK COMPANY

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Engine Overheating

Cooling System

Loose or broken circulating or pickup water pump belt	Adjust or replace belt (Sec. 7D)
Thermostat defective	Test thermostat and replace if defective (Sec. 7D)
Inaccurate temperature gauge or sender	Test gauge and sender; replace if defective (Sec. 3D)
Water pickup clogged with foreign material	Remove foreign material
Insufficient water pump operation	Repair water pump (Sec. 6A or 7D)
Pickup hose collapsed or kinked	Replace pickup hose with Mercury Marine approved water hose
Water shut-off valve closed or not completely open (if applicable)	Open shut-off valve
Sea strainer plugged (if applicable)	Clean or replace
Engine water passages plugged with foreign material	Locate and remove foreign material
Loose hose connections between pickup and pump inlet (sucking air)	Tighten loose connections
Pump will not hold prime	Check for leaks on pickup side of pump. Repair leaks. Check and repair pump if necessary (Sec. 7D)
Poor pickup location	Relocate pickup
Engine circulating pump defective	Replace circulating pump

Others

Spark plug wires crossed (wrong firing order)	Install spark plug wires in correct firing order (Sec. 8)
Improper engine ignition timing	Adjust timing (Sec. 1B)
Wrong heat range spark plugs (pre-igniting under load)	Replace spark plugs with proper heat range plugs (Sec. 8)
Cylinder head(s) warped or defective gasket(s) (would most likely have water in cylinders or signs of rust on valves)	Replace cylinder head gasket(s). Plane or replace head(s), if necessary (Sec. 5)
Insufficient lubrication of engine moving parts	Check and repair engine lubrication system (Sec. 5)
Engine "laboring" - at WOT, engine RPM below specifications	Check for proper propeller and condition of boat bottom
Sticking distributor advance mechanism prevents proper timing at various engine speeds.	Clean and/or repair distributor as needed (Sec. 3B)
Excessive exhaust back pressure, due to clogged exhaust elbows, bad muffles, stuck exhaust flappers, etc	Locate and repair
Valve timing off, due to jumped timing chain or improper valve adjustment	Adjust valve or reinstall timing chain properly (Sec. 5)
Rich air mixture in fuel	Repair restriction in fuel supply as needed (kinked fuel line, fuel pump bad, fuel filter clogged, dirty carburetor or incorrect jet size, anti-system valve causing restriction) (Sec. 4)
Boat cabin hot water heater not connected to engine properly	Correct improper connection

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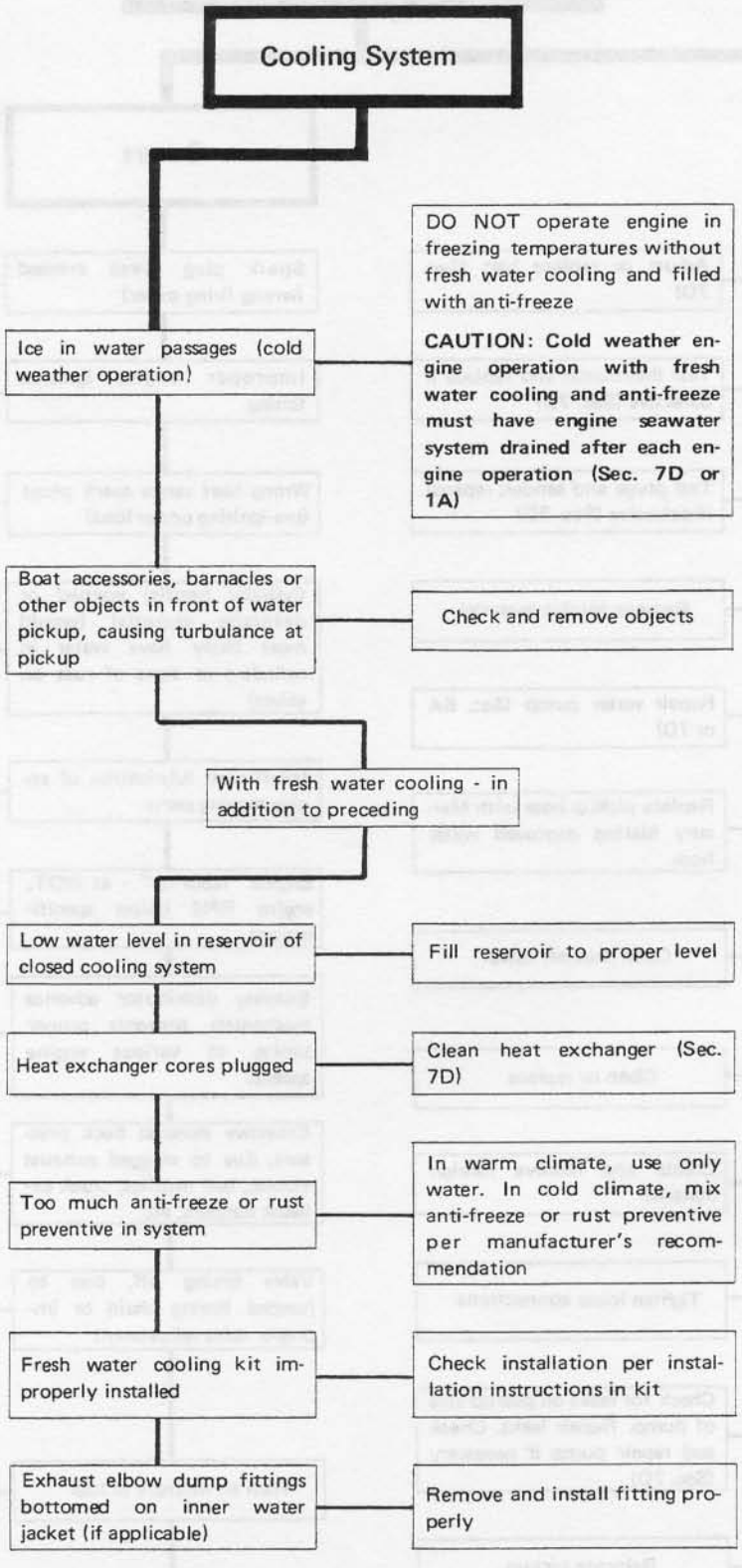


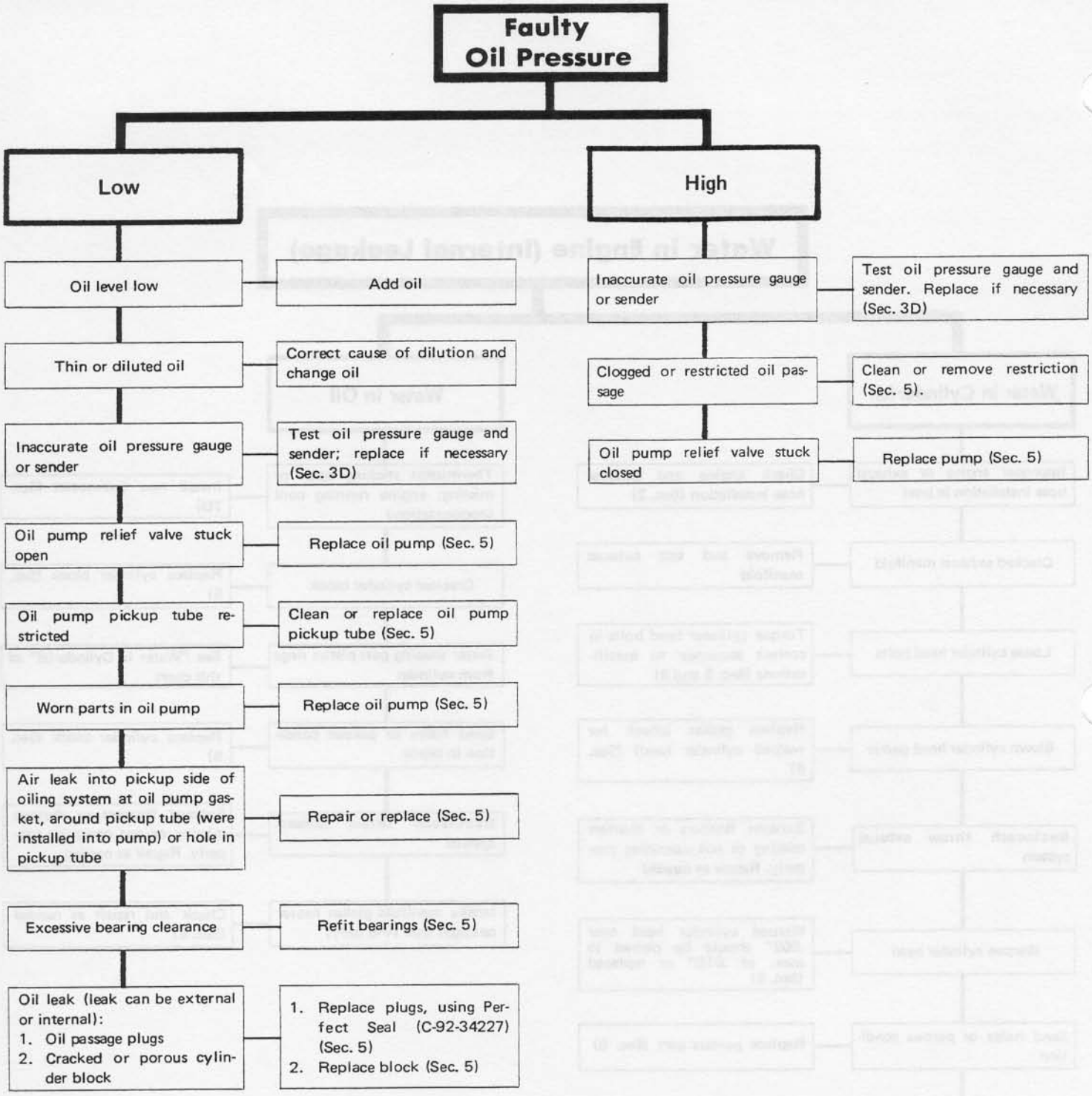
Water in Engine (Internal Leakage)

Water in Cylinder(s)

Improper engine or exhaust hose installation in boat	Check engine and exhaust hose installation (Sec. 2)
Cracked exhaust manifold	Remove and test exhaust manifold
Loose cylinder head bolts	Torque cylinder head bolts in correct sequence to specifications (Sec. 5 and 8)
Blown cylinder head gasket	Replace gasket (check for warped cylinder head) (Sec. 5)
Backwash throw exhaust system	Exhaust flappers or shutters missing or not operating properly. Repair as needed
Warped cylinder head	Warped cylinder head over .002" should be planed to max. of .010" or replaced (Sec. 5)
Sand holes or porous condition	Replace porous part (Sec. 5)
Cracked block in lifter chamber (V-8)	Replace cylinder block (Sec. 5)
Cracked cylinder wall	Replace cylinder block (Sec. 5)

Water in Oil

Thermostat sticking open or missing; engine running cool (condensation)	Install new thermostat (Sec. 7D)
Cracked cylinder block	Replace cylinder block (Sec. 5)
Water seeping past piston rings from cylinder	See "Water in Cylinder(s)" of this chart
Sand holes or porous condition in block	Replace cylinder block (Sec. 5)
Backwash throw exhaust system	Exhaust flappers or shutters missing or not operating properly. Repair as needed
Intake manifold gasket (water passage) leak (V-8 only)	Check and repair as needed (Sec. 5)


Faulty Oil Pressure
Low
Oil level low
Add oil
Thin or diluted oil
Correct cause of dilution and change oil
Inaccurate oil pressure gauge or sender
Test oil pressure gauge and sender; replace if necessary (Sec. 3D)
Oil pump relief valve stuck open
Replace oil pump (Sec. 5)
Oil pump pickup tube restricted
Clean or replace oil pump pickup tube (Sec. 5)
Worn parts in oil pump
Replace oil pump (Sec. 5)
Air leak into pickup side of oiling system at oil pump gasket, around pickup tube (were installed into pump) or hole in pickup tube
Repair or replace (Sec. 5)
Excessive bearing clearance
Refit bearings (Sec. 5)
Oil leak (leak can be external or internal):
1. Oil passage plugs
2. Cracked or porous cylinder block
1. Replace plugs, using Perfect Seal (C-92-34227) (Sec. 5)
2. Replace block (Sec. 5)
High
Inaccurate oil pressure gauge or sender
Test oil pressure gauge and sender. Replace if necessary (Sec. 3D)
Clogged or restricted oil passage
Clean or remove restriction (Sec. 5).
Oil pump relief valve stuck closed
Replace pump (Sec. 5)

Excessive Oil Consumption (MerCruiser Engine)

Oil leaks	Check bilge area for signs of oil. Wipe engine clean. Check engine oil level and add oil to proper level (if necessary). Place clean paper under engine to aid in detecting leakage. Run engine for approximately 20 minutes at 1200 RPM. Shut off engine and check for leakage at all gaskets, seals and oil passage plugs. Repair as needed
Normal engine oil consumption	It is normal for an engine (particularly new or newly overhauled engines) to use some oil, especially at wide-open-throttle (W.O.T.) operation. Engine (especially 4-cyl. engine) can consume one quart (.946 liter) (larger engines more) in 5 to 14 hours of W.O.T. operation. Refer to Sec. 1C ("Maintaining Oil Level"), also Service Bulletin 67-12
Oil level too high	Drain oil to proper level (Sec. 1C). Check that proper dipstick is being used. If oil is diluted with water or gasoline, locate and repair cause of dilution
Oil too thin	Replace with recommended oil (Sec. 1C)
Low compression due to piston rings improperly installed, worn, scuffed, broken, stuck in grooves, incorrect size rings, or ring grooves worn. Worn, scored, tapered and/or out-of-round cylinder walls or cracked piston	Check engine compression (Sec. 1B), using oil in cylinders to help locate area of compression loss. If compression is low because of piston rings, this probably also is cause of oil consumption. Repair as needed (Sec. 5). If compression is normal, continue with next step
Improper seating of rings during break-in	Replace rings as outlined in Sec. 5. Instruct customer on break-in procedure
Valve seals damaged, missing or loose	Remove rocker arm cover(s) and inspect valve seals. Repair as needed (Sec. 5)
Plugged drain-back holes in cylinder head (not allowing proper oil return to oil pan)	Remove rocker arm cover(s) and inspect drain-back holes. Clean if needed
Worn valve stems or valve guides	Remove cylinder head(s); check and repair as needed (Sec. 5)

Noisy Engine Operation

Refer to Section 5 for needed mechanical repairs.

No definite rule or test will positively determine source of noise; therefore, following information can be used only as general guide to noise diagnosis.

Use a timing light to determine if noise is timed with engine speed or one-half engine speed. Noises, timed to engine speed, are related to crankshaft, rods, pistons and wrist pins. Noises at one-half engine speed are valve train related.

Use stethoscope to aid in locating noise source; however, because noise will travel to other metal parts not involved in problem, caution must be exercised.

After utilizing above procedures, if it is suspected that noise is confined to one particular cylinder, ground spark plug leads one-at-a-time. If noise lessens noticably or disappears, it is isolated to that particular cylinder.

Noises Timed to Engine Speed

Noises Timed to ½ Engine Speed (on Following Pages)

Other Noises (on Following Pages)

Piston(s) and/or piston ring(s) noise

- Excessive clearance between piston and bore
  NOTE: Noise lessens as engine warms up. Noise loudest at low speed, under load and when cold
- Improper piston pin fit
- Excessive accumulation of carbon in heads and/or on piston tops
- Connecting rods and improperly aligned
- Excessive clearance between rings and grooves
- Rings broken and/or pistons cracked. Refer to "Causes of rings breaking", right

Causes of rings and/or piston breaking

- Improper installation

Connecting rod(s) noise

- Insufficient oil supply

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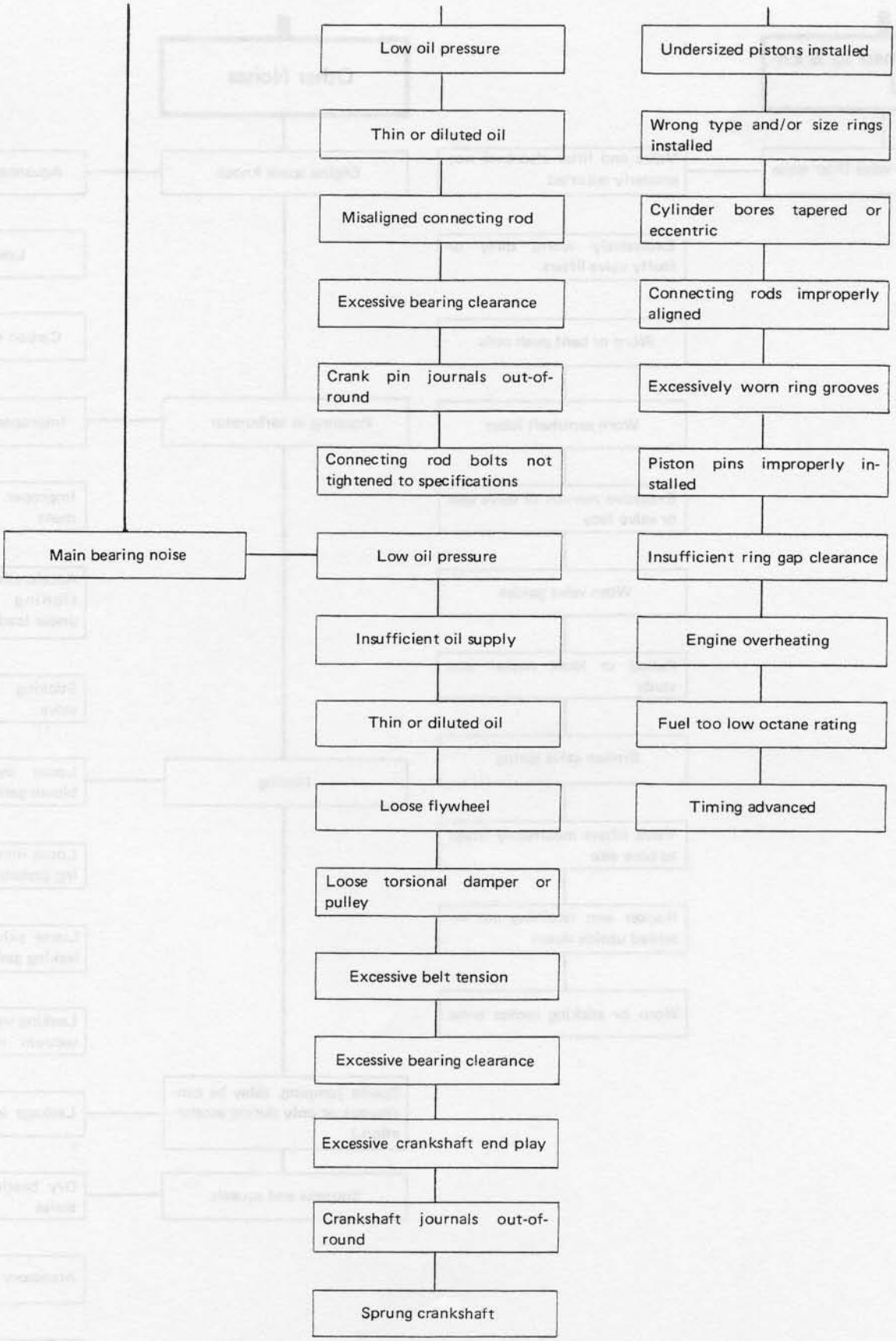

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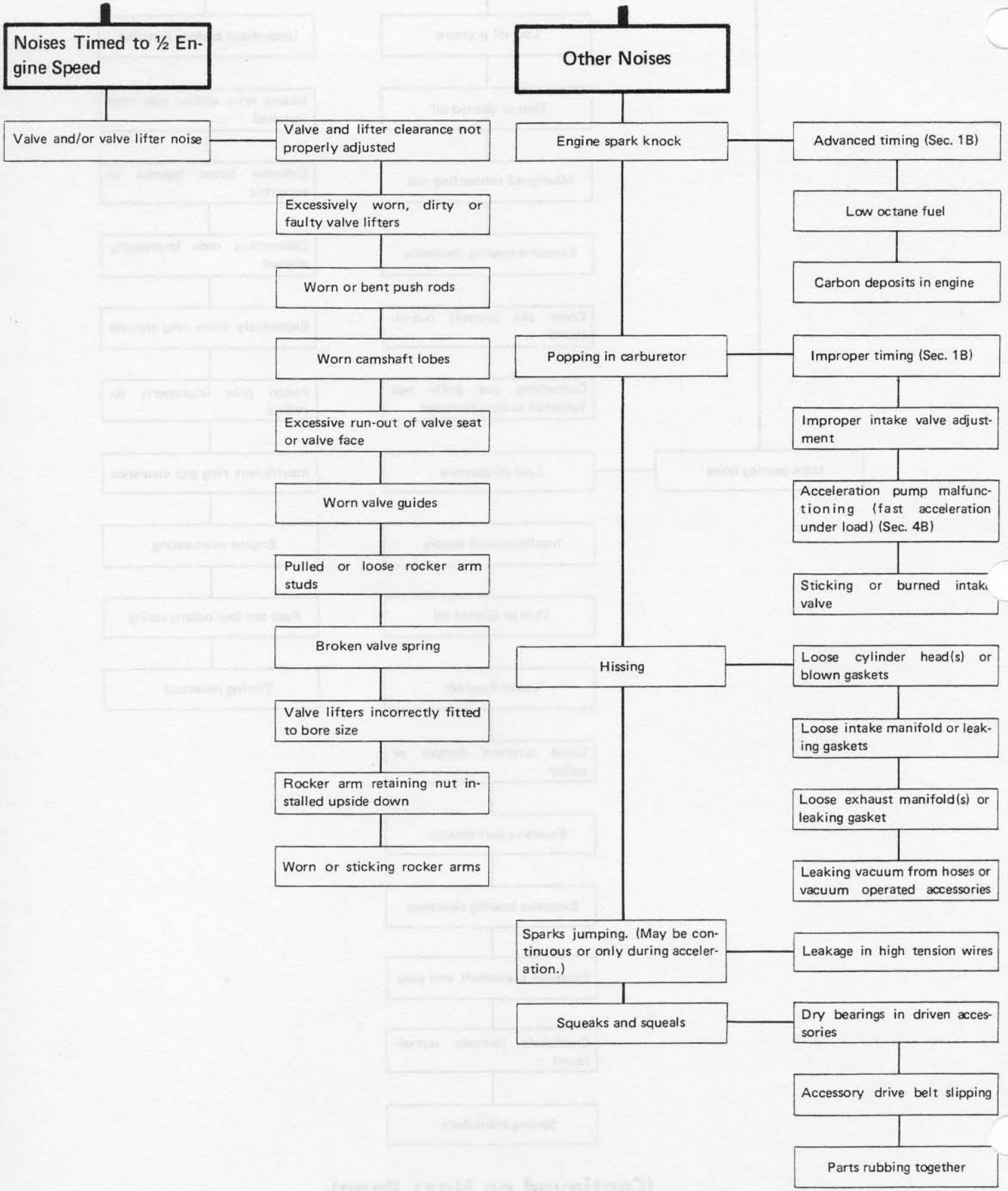


Poor Fuel Economy

Fuel leaks	**CAUTION: Be careful of fuel leaks. Gas vapor build-up is explosive.** Carefully inspect carburetor, fuel pump, fuel tank, fuel lines, filters, valves and all connections for leakage. Repair as needed
Engine needs tune-up	Check and tune up engine as needed (Sec. 1B)
Bent, damaged or incorrect pitch propeller	Repair propeller as needed. Water test boat with different propellers to obtain proper maximum RPM
Dirty or damaged boat bottom (marine growth)	Clean and resurface boat bottom
Improper trim tab adjustment	Adjust as needed (Sec. 1A)
Improper fuel	Use only fuel recommended for a particular product
Operator habits	Inform operator of correct procedures and proper operating methods for conserving fuel, following
	Avoid unnecessary idling
	Accelerate quickly and get hull trimmed out as soon as possible
	After boat is on plane, cut back to ¾-throttle. Up to 50% savings in fuel
	Carry essential gear only (less weight)
	Balance weight of passengers and gear in boat
	Service engine and propeller periodically by an authorized MerCruiser dealer
Boat under-powered (engine laboring)	Check horsepower-to-boat weight ratio. Refer to boat manufacturer
Restricted exhaust system	Check exhaust passages for foreign material
Incorrect engine operating temperature	Repair or replace components as necessary
Inoperative positive crankcase ventilation system	Clean or repair as needed
Partly clogged flame arrestor	Clean or replace as necessary
Automatic choke binding, sticking and/or improper adjustment	Check and repair as needed. Adjust to specifications (Sec. 4B)
Improper idle fuel mixture and/or idle RPM settings	Adjust, using correct procedure (Secs. 1B and 4B)
Accelerator pump stroke out-of-adjustment	Adjust to specification (Sec. 4B)
Accelerator linkage binding, sticking and/or improperly adjusted	Repair and adjust as needed (Sec. 2)
Excessive fuel pump pressure	Check fuel pump pressure (Sec. 4A)
Carburetor flooding	Check and repair as needed (Sec. 4B)
Carburetor jets worn or damaged, sticking power valve, obstructed air bleed(s) and/or damaged or leaking gaskets	Dissassemble carburetor and repair as needed (Sec. 4B)
Low engine compression	Check and repair as needed (Secs. 1B and 5)

Engine Cranks but Will Not Start or Starts Hard

Ignition System (Conventional) with Battery in Good Condition

CAUTION: Keep area well-ventilated. Gas vapor build-up is explosive.
Check for spark at coil high tension lead by removing lead from distributor cap and installing spark tester between coil lead and engine block (ground). Crank engine and check for spark

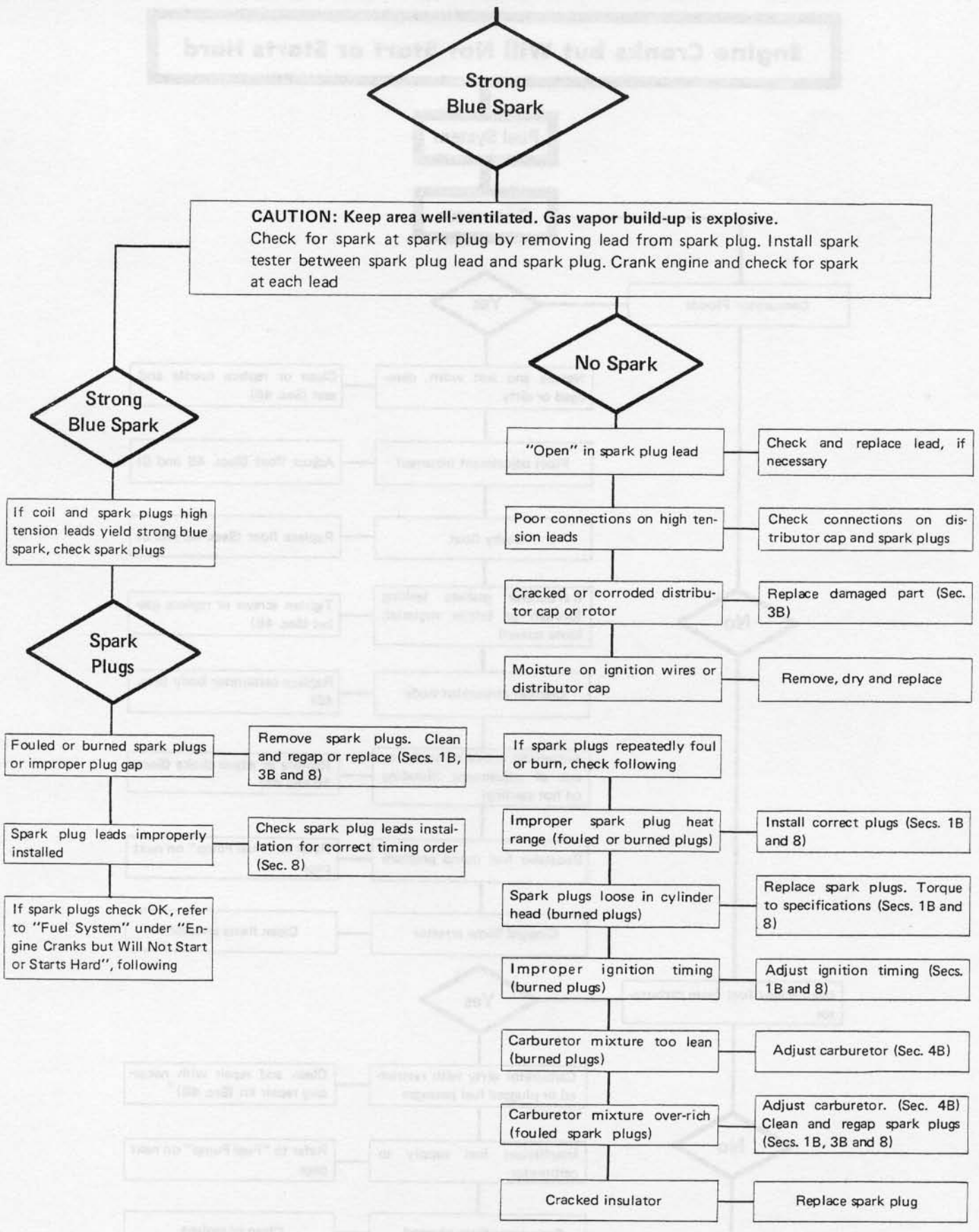
No Spark, Weak-Red or Yellow Spark

Poor connections or damaged ignition wiring	Check all connections and wiring (Sec. 3E)
Shorted tachometer (tach which is wired in series with coil)	Check tachometer; replace if necessary (Sec. 3D)
Ignition points improperly gapped, burned or dirty	Clean and regap ignition points or replace points (Secs. 1B, 3B and 8)
Faulty ignition key switch	Check key switch and replace if necessary (Sec. 3D)
Faulty condenser	Test condenser; replace if defective (Secs. 3B and 8)
Faulty coil	Test coil and replace if defective (Secs. 3B and 8)
Faulty ballast or resistance wire	Test ballast or resistance wire; replace if necessary (Sec. 8)
Improper ignition timing	Adjust timing with timing light (Secs. 1B and 8)

Strong Blue Spark (See Next Page)

If ignition points repeatedly pit or burn, check following

Dirt or oil on ignition points	Check distributor oil seal (Sec. 3B)
Ignition points misaligned or gap too small	Align and adjust contacts (Secs. 3B and 8)
Wrong condenser or faulty condenser	Test condenser and replace if necessary (Secs. 3B and 8)
Faulty ignition switch	Test switch and replace if necessary (Sec. 3D)
Faulty coil	Test coil and replace if necessary (Secs. 3B and 8)
Alternator output too high	Test alternator output and voltage regulator (Sec. 3C)
Bushings or distributor shaft worn	Recondition or replace distributor (Sec. 3B)
Ballast or resistor wire not in circuit	Install ballast or resistor wire in circuit (Sec. 3E)
Improper timing	Check and adjust with timing light (Secs. 1B and 8)
Faulty distributor advance mechanism causing timing to vary	Check and repair as needed (Sec. 3B)
Bent distributor rotor shaft	Check and replace distributor if bent


Strong Blue Spark
CAUTION: Keep area well-ventilated. Gas vapor build-up is explosive.
Check for spark at spark plug by removing lead from spark plug. Install spark tester between spark plug lead and spark plug. Crank engine and check for spark at each lead
No Spark
"Open" in spark plug lead
Check and replace lead, if necessary
Poor connections on high tension leads
Check connections on distributor cap and spark plugs
Cracked or corroded distributor cap or rotor
Replace damaged part (Sec. 3B)
Moisture on ignition wires or distributor cap
Remove, dry and replace
If spark plugs repeatedly foul or burn, check following
Improper spark plug heat range (fouled or burned plugs)
Install correct plugs (Secs. 1B and 8)
Spark plugs loose in cylinder head (burned plugs)
Replace spark plugs. Torque to specifications (Secs. 1B and 8)
Improper ignition timing (burned plugs)
Adjust ignition timing (Secs. 1B and 8)
Carburetor mixture too lean (burned plugs)
Adjust carburetor (Sec. 4B)
Carburetor mixture over-rich (fouled spark plugs)
Adjust carburetor. (Sec. 4B) Clean and regap spark plugs (Secs. 1B, 3B and 8)
Cracked insulator
Replace spark plug
Strong Blue Spark
If coil and spark plugs high tension leads yield strong blue spark, check spark plugs
Spark Plugs
Fouled or burned spark plugs or improper plug gap
Remove spark plugs. Clean and regap or replace (Secs. 1B, 3B and 8)
Spark plug leads improperly installed
Check spark plug leads installation for correct timing order (Sec. 8)
If spark plugs check OK, refer to "Fuel System" under "Engine Cranks but Will Not Start or Starts Hard", following

Engine Cranks but Will Not Start or Starts Hard

Fuel System

Carburetor

Carburetor Floods — Yes

- Needle and seat worn, damaged or dirty — Clean or replace needle and seat (Sec. 4B)
- Float adjustment incorrect — Adjust float (Secs. 4B and 8)
- Leaky float — Replace float (Secs. 4B and 8)
- Carburetor gaskets leaking (broken or brittle material; loose screws) — Tighten screws or replace gasket (Sec. 4B)
- Cracked carburetor body — Replace carburetor body (Sec. 4B)
- Automatic choke defective or out of adjustment (flooding on hot starting) — Replace or adjust choke (Secs. 1B and 4B)
- Excessive fuel pump pressure — Refer to "Fuel Pump" on next page
- Clogged flame arrestor — Clean flame arrestor

No

Insufficient fuel from carburetor — Yes

- Carburetor dirty with restricted or plugged fuel passages — Clean and repair with necessary repair kit (Sec. 4B)
- Insufficient fuel supply to carburetor — Refer to "Fuel Pump" on next page
- Carburetor filter plugged — Clean or replace

No

Refer to "Fuel Pump" and "Other" (following) of these "Fuel System" charts

Engine Cranks but Will Not Start or Starts Hard

Fuel System

Fuel Pump

Insufficient Fuel

- No → Excessive Fuel
  - Yes → Check for excessive fuel pump pressure (Sec. 4A)
  - No → Refer to "Carburetor" and "Others" on immediate preceding and following pages
- Yes

Vent in fuel tank restricted or plugged	Clean or replace (this also will cause a collapsed fuel tank)
Fuel shut-off valve closed	Open shut-off valve
Check pump volume	(Sec. 4A)
Check pump pressure (too low)	(Secs. 4A and 1B)
Leak on pressure side of system is evident from dripping fuel	Repair
Leak in suction side of system does not drip fuel but takes in air; this would reduce volume of fuel on pressure side	Repair
Fuel tank pickup restricted or plugged	Clean or replace (also clean tank)
Restricted or plugged fuel filter	Replace fuel filter
Incorrect fuel pump	Replace with proper pump
Vapor lock	Check for insufficient ventilation in engine compartment. Check for correct fuel line routing and fuel line support so fuel line will not lie against engine block and overheat fuel
Water frozen in fuel lines (cold temperature operation)	**CAUTION: Do Not use open flame.** Thaw frozen fuel line

Refer to "Others", following under "Fuel System"

Engine Cranks but Will Not Start or Starts Hard

Fuel System

Others

- Fuel tank empty → Check for fuel in tank
- Fuel shut-off valve closed → Open fuel shut-off valve

CAUTION: When using following procedure, extreme care must be taken that raw fuel is not allowed to spill into engine compartment. After test is completed, reconnect original fuel supply and check carefully for leaks.
Operate engine, using remote fuel supply, such as an outboard fuel tank, to eliminate the following

Engine Runs Good with Remote Fuel Tank

- Poor fuel or stale fuel → Run engine with remote tank. If engine operation is satisfactory, replace fuel
- Water in fuel → Remove all contaminated fuel and replace with clean fuel
- Fuel shut-off valve or anti-siphon valve (installed by boat manufacturer) in fuel line → Check valve for: Too small orifice, partially closed or closed, valve fluctuates between open and closed position
- Fuel tank pickup screen plugged → Clean or replace
- Leak in suction side of system (takes in air) → Repair as needed

If water continues to enter fuel system, find and correct source of water supply as follows

- Fuel tank filler cap missing, loose or poor fit
- Water enters thru fuel tank vent
- Leak in top of fuel tank (hole in tank, fuel gauge sender gasket leak)
- Condensation in fuel tank (usually during long storage periods)

Engine Does Not Run or Runs Poor with Remote Fuel Tank

- Low or uneven compression → Check engine compression (Sec. 1B)
- Vacuum leak → Check carburetor base and its gasket and intake manifold and its gasket. If equipment has vacuum power shift, check for vacuum leak
- Valve timing incorrect → Check and adjust as needed (Sec. 5)
- Refer to "Carburetor" and "Fuel Pump" under "Fuel System", preceding

Engine Starts but Runs Poorly

Engine Idles Poorly

- Corroded wire ends or distributor towers — Clean or replace parts as needed
- Dirty or clogged flame arrestor — Remove and clean flame arrestor
- Improper idle fuel mixture setting(s) — Adjust idle fuel mixture screws according to procedure (Sec. 1B)
- Moisture on ignition wires, distributor cap or spark plugs — Clean and check insulation
- Cracked or dirty distributor cap or rotor — Inspect contacts and surfaces. Clean or replace (Sec. 3B)
- Incorrect distributor point gap or burned or pitted points — Adjust or replace as needed (Secs. 1B and 8)
- Fouled spark plugs, cracked porcelain or improper gap — Clean, gap or replace spark plugs (Sec. 3B)

Caution: When using following procedure, extreme care must be taken so that raw fuel is not allowed to spill into engine compartment. After test is completed, reconnect original fuel supply and check carefully for leaks.
Operate engine, using remote fuel supply (such as an outboard fuel tank).

Engine Runs Poorly with Remote Fuel Tank (Following Page)

Engine Acceleration Is Poor (Following)

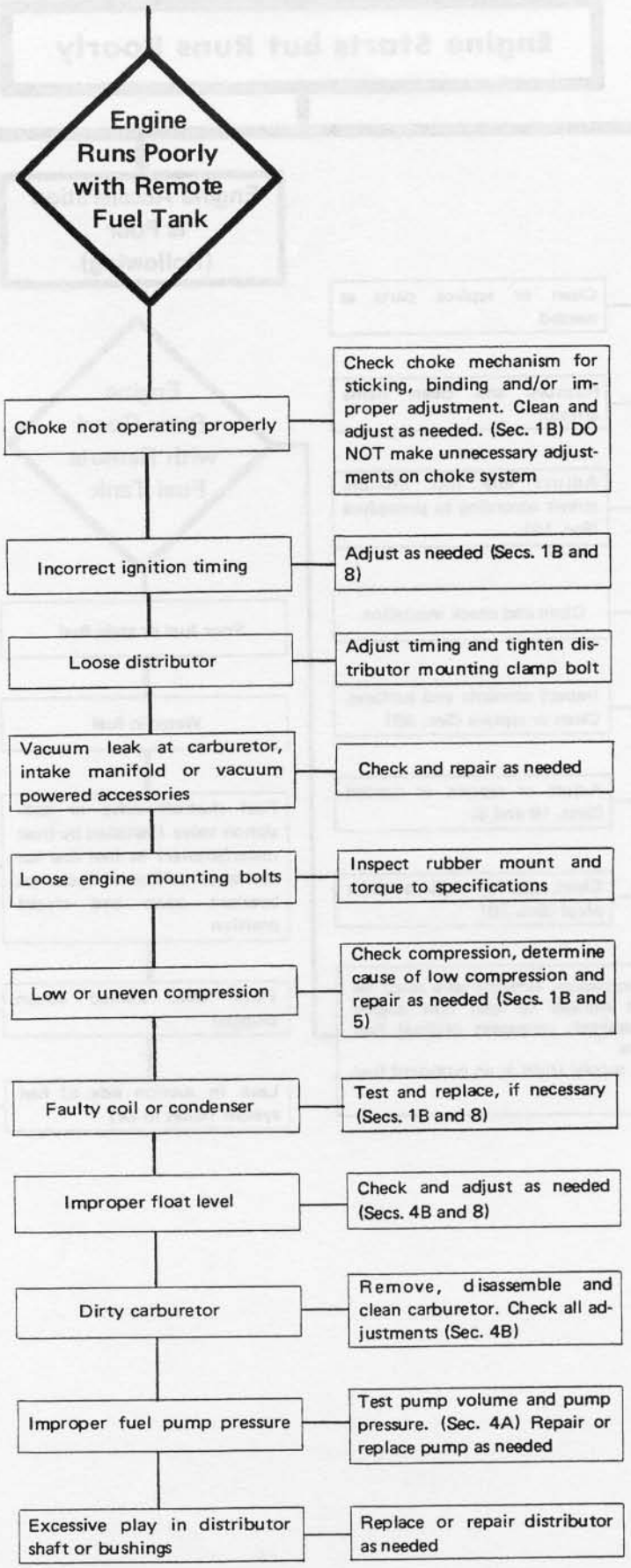
Engine Runs Good with Remote Fuel Tank

- Poor fuel or stale fuel — Remove all fuel and replace with clean fuel
- Water in fuel — Remove all contaminated fuel and replace with clean fuel
- Fuel shut-off valve or anti-siphon valve (installed by boat manufacturer) in fuel line has too small orifice or fluctuates between open and closed position — Check and replace with proper size orifice, if necessary
- Fuel tank pickup screen plugged — Clean or replace
- Leak in suction side of fuel system (takes in air) — Repair as needed

Engine Runs Poorly at High RPM (Following)

If water continues to enter fuel system, find and correct source of water supply. See following

- Fuel tank filler cap missing, loose or poor fit
- Water enters thru fuel tank vent
- Leak in top of fuel tank (hole in tank or fuel gauge sender gasket leak)
- Condensation in fuel tank (usually during long storage periods)


Engine Runs Poorly with Remote Fuel Tank
Choke not operating properly
Check choke mechanism for sticking, binding and/or improper adjustment. Clean and adjust as needed. (Sec. 1B) DO NOT make unnecessary adjustments on choke system
Incorrect ignition timing
Adjust as needed (Secs. 1B and 8)
Loose distributor
Adjust timing and tighten distributor mounting clamp bolt
Vacuum leak at carburetor, intake manifold or vacuum powered accessories
Check and repair as needed
Loose engine mounting bolts
Inspect rubber mount and torque to specifications
Low or uneven compression
Check compression, determine cause of low compression and repair as needed (Secs. 1B and 5)
Faulty coil or condenser
Test and replace, if necessary (Secs. 1B and 8)
Improper float level
Check and adjust as needed (Secs. 4B and 8)
Dirty carburetor
Remove, disassemble and clean carburetor. Check all adjustments (Sec. 4B)
Improper fuel pump pressure
Test pump volume and pump pressure. (Sec. 4A) Repair or replace pump as needed
Excessive play in distributor shaft or bushings
Replace or repair distributor as needed

Engine Starts but Runs Poorly

Engine Acceleration Is Poor

Inoperative accelerator pump. **Caution: DO NOT run engine with flame arrestor removed.** With engine not running and ignition switch in off position, remove flame arrestor. While observing accelerator pump discharge passage, operate engine throttle to full throttle position. A stream of raw fuel should be discharged from passage. If proper discharge is observed, continue with chart. Reinstall flame arrestor	Check and adjust throttle system for full throttle operation (Sec. 2) Check and adjust accelerator pump rod adjustment (Sec. 4B) Check and adjust fuel float level (Sec. 4B) — If fuel level is low and float level adjustment is correct, then check for poor or restricted fuel supply, following. Refer to Troubleshooting Chart of this section, "Engine Cranks but Will Not Start", "Fuel System" Replace accelerator pump assembly (Sec. 4B)
Check automatic choke for sticking partly closed	Repair as needed (Sec. 4B)
Improper spark plug heat range	Install correct plugs (Sec. 8)
Fouled spark plugs or improper gap	Clean and regap or replace with proper spark plug (Secs. 1B, 3B and 8)
Cracked or dirty distributor cap or rotor	Inspect contacts and surfaces. Clean or replace (Sec. 3B)
Distributor contact points dirty or improperly gapped	Regap or replace as needed (Secs. 1B, 3B and 8)
Distributor not advancing properly	Check and repair as needed (Sec. 3B)
Incorrect ignition timing	Set timing with timing light (Secs. 1B and 8)
Poor connections or damaged ignition wiring	Check condition of wires and tighten all connections
Coil or condenser defective	Test and replace as needed (Secs. 3B and 8)
Make compression and intake manifold vacuum tests to determine condition of mechanical components of engine (Sec. 1B)	Repair as needed (Sec. 5)

Engine Starts but Runs Poorly

Engine Runs Poorly at High RPM

Incorrect ignition timing	Adjust timing, using timing light (Sec. 1B)
Distributor contact points dirty or incorrectly gapped	Adjust or replace contact points (Secs. 1B and 3B)
Distributor cap or rotor cracked or burned	Check and replace if necessary (Sec. 3B)
Incorrect spark plug heat range	Install correct spark plugs (Sec. 8)
Spark plugs dirty or gap set too wide	Clean and adjust or replace spark plugs
Shorting (poor insulation) high tension wiring (sparks jumping to ground)	Replace bad high tension wire
Insufficient fuel supply (also poor acceleration)	Refer to Troubleshooting Chart of this section, "Engine Cranks but Will Not Start," subhead "Fuel System"
Faulty ignition wiring or loose connection	Check and repair as needed
Defective coil or condenser	Test and replace parts as needed (Sec. 1B)
Restricted exhaust system	Repair as needed
Restricted crankcase ventilation system	Check and clean or repair as needed
Engine overheating	Check operating temperature for overheating. If engine is overheating, refer to Troubleshooting Chart of this section, "Engine Overheating"
Excessive play in distributor shaft	Check distributor shaft and bushings for wear. Repair as needed (Sec. 3B)
Distributor shaft cam worn	Check cam. Replace if necessary (Sec. 3B)
Low compression	Take compression test. (Sec. 1B) If compression is low, make repairs as needed (Sec. 5)

Improper Full Throttle Engine RPM (MerCruiser Stern Drive and Inboard)

Low RPM

Damaged propeller	Check and repair or replace propeller as needed
Propeller pitch too great	Water test boat with lower pitch propeller to obtain proper maximum RPM
Propeller diameter too great (inboard only)	Water test boat with lesser pitch and/or diameter propeller
Dirty or damaged boat bottom (marine growth)	Clean and resurface boat bottom
Improper drive unit trim angle (in too far)	Water test boat, using different drive unit angle settings
Improper timing and/or dwell	Check and adjust as needed (Sec. 1B)
Engine ignition system malfunctioning	Refer to Troubleshooting Chart (of this section), "Engine Starts but Runs Poorly"
Incorrect fuel supply to engine	Refer to Troubleshooting Chart (of this section), "Engine Starts but Runs Poorly"
Drive installation too low on boat transom	Check with boat manufacturer
Permanent "hook" in boat bottom. **NOTE: Some boats are designed with a slight "hook" in boat for correct performance**	Check with minimum 6 ft. (1.83m) straight edge from transom for "hook" in boat bottom. If hook is found, contact boat manufacturer
"Power hook" in boat bottom (develops "hook" under power only; weak boat bottom)	Water test boat. Boat will perform normal until "hook" develops at high speed, then loss of RPM and speed will occur

High RPM

Propeller pitch too low	Water test boat with greater pitch propeller
Propeller diameter too small (inboard only)	Water test boat with greater pitch and/or diameter propeller
Propeller hub slipping (stern drive only)	Repair or install new propeller
Improper drive unit trim angle (out too far)	Water test boat, using different drive unit angle settings
Water pickup or other accessories located in line with and too close to propeller (causing cavitation)	Relocate water pickup away from in front of propeller
Keel located too close to propeller and/or too deep in water (causing cavitation)	Remove keel 4 ft. (1.22m) forward of transom
Drive installation too high on boat transom	Check with boat manufacturer
Engine coupler slipping	Replace coupler

Poor Boat Performance and/or Poor Maneuverability (MerCruiser Stern Drive and Inboard)

Bow Too Low

- Improper drive unit trim angle
  - Water test boat, using different drive unit angle settings
- Weight distribution (heavy in bow [front] of boat)
  - Relocate stored gear from bow (front) of boat to stern (rear) and water test boat. If bow overweight is caused by permanently installed fuel tank(s) etc, contact boat manufacturer
- Under-powered
  - Check horsepower-to-boat weight ratio. Refer to boat manufacturer
- Permanent "hook" in boat bottom.
  NOTE: Some boats are designed with a slight "hook" in boat bottom for correct performance
  - Check with minimum 6 ft. (1.83m) straight edge from transom for "hook" in boat bottom. If hook is found, contact boat manufacturer
- "Power hook" in boat bottom (develops "hook" under power only; weak boat bottom)
  - Water test boat. Boat will perform normal until "hook" develops at high speed, then loss of RPM and speed will occur

Bow Too High

- Improper drive unit trim angle
  - Water test boat, using different drive unit angle settings
- Propeller pitch too great (also low RPM)
  - Water test boat with lower pitch propeller to obtain proper maximum RPM
- Dirty boat bottom (marine growth)
  - Clean boat bottom and retest boat
- Poor running engine
  - Refer to Troubleshooting Chart (this section), "Engine Starts but Runs Poorly"
- Weight distribution (heavy in stern [rear] of boat)
  - Relocate stored gear from stern (rear) to bow (front) of boat and water test. If stern overweight is caused by permanently installed fuel tank(s) etc, contact boat manufacturer
- "Rocker" in boat bottom
  - Check with minimum 6 ft. (1.83m) straight edge from transom for "rocker" in boat bottom. If "rocker" is found, contact boat manufacturer

Propeller Cavitating

- Drive unit installation too high on boat transom
  - Check with boat manufacturer
- Dirty or rough boat bottom (marine growth)
  - Clean and/or resurface boat bottom
- Damaged propeller
  - Repair or replace propeller as needed
- Keel located too close to propeller and/or too deep in water
  - Remove keel 4 ft. (1.22m) forward of transom
- Water pickup or other accessories located in line with and too close to propeller
  - Relocate water pickup away from in front of propeller
- Hook in bottom of boat
  - Check with minimum 6 ft. (1.83m) straight edge from transom for "hook" in boat bottom. If "hook" is found, contact boat manufacturer

71 and 72 Series Transmission Malfunctions

NOTE: Refer to Section 6D for Detailed Instructions on Draining, Filling and Repairing Transmission.

- Transmission Malfunctions in Neutral — *Below*
- Transmission Malfunctions in Forward Range — *On Following Page*
- Transmission Malfunctions in Reverse Range — *Following*
- Transmission Malfunctions in All Ranges — *Following*
- Internal and External Leaks — *Following*
- Miscellaneous Transmission Problems — *Following*

71 and 72 Series Transmission Malfunctions

NOTE: Refer to Section 6D for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in Neutral

Output shaft drags excessively in forward rotation	Shift linkage improperly adjusted	Adjust shift linkage, using proper procedure
	Forward clutch improperly assembled	Remove and disassemble transmission. Reassemble clutch assembly correctly
	Damaged or broken belleville clutch springs	Remove transmission and replace clutch spring
	Damaged forward clutch plate(s)	Remove transmission and replace damaged or worn parts
Output shaft drags excessively in reverse rotation	Shift linkage improperly adjusted	Adjust shift linkage, using proper procedure
	Reverse clutch improperly assembled	Remove and disassemble transmission. Reassemble reverse clutch assembly correctly
	Damaged reverse clutch plate(s)	Remove transmission and replace worn or damaged parts
	Damaged or broken clutch springs	Remove transmission and replace clutch springs
	Planetary gear failure	Remove transmission and replace or repair as necessary

71 and 72 Series Transmission Malfunctions

NOTE: Refer to Section 6D for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in Forward Range

Low oil pressure	Dirty oil screen	Drain transmission oil. Remove and clean or replace oil screen. Refill transmission with clean oil
	Low oil level	Add oil to proper level
	Regulator valve stuck or inoperative	Replace valve
	Worn oil pump	Remove transmission and replace oil pump
Forward clutch engages improperly	Shift linkage improperly adjusted	Adjust shift linkage, using proper procedure
	Sheared forward clutch hub drive key	Remove transmission and replace key
	Worn or misaligned bushings in transmission case	Remove transmission and replace bushings. Follow installation instructions
	Worn or damaged clutch piston oil seals and/or clutch sealing rings	Remove transmission and replace seals
	Clutch improperly assembled	Remove and disassemble transmission. Reassemble clutch assembly correctly
	Damaged or broken belleville clutch spring	Remove transmission and replace clutch spring
	Worn or damaged clutch plate(s)	Remove transmission and replace damaged or worn parts
Forward clutch slips (fails to fully engage)	Shift linkage improperly adjusted	Adjust shift linkage, using proper procedure
	Clutch improperly assembled	Remove and disassemble transmission. Reassemble clutch assembly correctly
	Damaged or broken belleville clutch spring	Remove transmission and replace clutch spring
	Worn or damaged clutch plate(s)	Remove transmission and replace damaged or worn parts
Reduction unit failure (inboard only)	Planetary gear failure	Remove transmission and replace or repair as necessary

71 and 72 Series Transmission Malfunctions

NOTE: Refer to Section 6D for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in Reverse Range

Low oil pressure	Dirty oil screen	Drain transmission oil. Remove and clean or replace oil screen. Refill transmission with clean oil
	Low oil level	Add oil to proper level
	Regulator valve stuck or inoperative	Replace valve
	Worn oil pump	Remove transmission and replace oil pump
Reverse clutch engages improperly	Shift linkage improperly adjusted	Adjust shift linkage, using proper procedure
	Worn or damaged clutch piston oil seals	Remove transmission and replace seals
	Reverse clutch improperly assembled	Remove and disassemble transmission. Reassemble clutch assembly correctly
	Worn or damaged clutch plate(s)	Remove transmission and replace damaged or worn parts
	Damaged or broken clutch springs	Remove transmission and replace clutch spring(s)
Reverse clutch slips (fails to engage fully)	Shift linkage improperly adjusted	Adjust shift linkage, using proper procedure
	Reverse clutch improperly assembled	Remove and disassemble transmission. Reassemble clutch assembly correctly
	Worn or damaged reverse clutch plate(s)	Remove transmission and replace worn or damaged parts
	Damaged or broken clutch springs	Remove transmission and replace clutch springs
Reverse gear set failure	Planetary gear failure	Remove transmission and replace or repair as necessary
Reduction gear set failure	Planetary gear failure	Remove transmission and replace or repair as necessary

71 and 72 Series Transmission Malfunctions

NOTE: Refer to Section 6D for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in All Ranges

No oil pressure	No oil	Fill transmission to proper level. Run and check transmission for possible damage
	Pump improperly installed for engine rotation	Remove transmission and locate correctly
	Sheared oil pump drive key	Remove transmission and replace key
Low oil pressure	Dirty oil screen	Drain transmission oil. Remove and clean or replace oil screen. Refill transmission with clean oil
	Low oil level	Add oil to proper level
	Regulator valve stuck or inoperative	Replace valve
	Worn oil pump	Remove transmission and replace oil pump
High oil temperature	Water in transmission oil from damaged oil cooler	Replace oil cooler
	Low oil level	Add oil to proper level
	High oil level	Drain oil to proper level
	Low water supply to oil cooler (engine also overheating)	Repair pickup water pump
	Dirty or restricted oil cooler	Clean or replace oil cooler
	Planetary gear failure	Remove transmission and replace or repair as necessary
Failure of reduction gear	Planetary gear failure	Remove transmission and replace or repair as needed

71 and 72 Series Transmission Malfunctions

NOTE: Refer to Section 6D for Detailed Instructions on Draining, Filling and Repairing Transmission.

Internal and External Leaks

Oil leaks at pump	Loose bolts	Remove transmission and torque bolts to specifications (Sec. 8)
	Damaged gasket	Remove transmission and replace pump gasket
	Damaged oil seal	Remove transmission and replace oil seal
	Foreign material on mating surfaces	Remove transmission and remove pump housing. Clean mating surfaces and re-install pump with new gasket
Oil on exterior of transmission	Loose bolts or oil line fittings	Tighten bolts and/or fittings
	Oil filler plug or cap leaks	Replace or tighten
	Damaged control valve "O" ring	Replace "O" ring
	Damaged gasket	Remove transmission and replace gasket
	Porous transmission housing	Replace transmission housing
	Foreign material on mating surfaces	Remove transmission and remove part that is leaking. Clean mating surfaces and reinstall with new gasket
Oil leaks at rear bearing retainer	Loose bolts	Torque bolts to specifications (Sec. 8)
	Damaged gasket	Replace gasket (transmission may need to be removed)
	Damaged oil seal	Replace oil seal (transmission may require removal)
	Foreign material on mating surfaces	Remove leaking part. Clean mating surfaces and reinstall with new gasket. Transmission may need to be removed
Water in transmission oil	Damaged oil cooler	Replace oil cooler

71 and 72 Series Transmission Malfunctions

NOTE: Refer to Section 6D for Detailed Instructions on Draining, Filling and Repairing Transmission.

Miscellaneous Transmission Problems

Gear noise - forward	Inadequate torque on output shaft nut	Torque to specifications (Sec. 8)
	Nicks on gears	Remove nicks with stone or replace gears
Gear noise - reverse	Inadequate torque on output shaft nut	Torque to specifications
	Nicks on gears	Remove nicks with stone or replace gears
	Planetary gear failure	Remove transmission and replace or repair as needed
Pump noise	Low oil level	Add oil to proper level
	Worn oil pump	Remove transmission and replace oil pump assembly
	Nicks on gears	Remove nicks with stone or replace pump assembly
Shifts hard	Regulator valve stuck	Replace valve
	Shift linkage improperly adjusted	Adjust shift linkage, using proper procedure
	Control lever and poppet ball corroded	Clean and lubricate
	Shift linkage interference	Check and repair as needed
	Damaged control valve "O" ring	Replace "O" ring
High oil pressure	Regulator valve stuck	Replace valve
	Wrong oil used in transmission	Change oil, using recommended oil
	Cold oil (usually during cool temperatures)	Run engine until oil reaches normal operating temperature. Recheck oil pressure

MerCruiser II-TR Transmission Model A Malfunctions

NOTE: Refer to Section 6E for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in Neutral	Transmission Malfunctions in Forward	Transmission Malfunctions in Reverse	Transmission Malfunctions in All Ranges	Internal and External Leaks	Miscellaneous Transmission Problems
Below	*On Following Page*	*Following*	*Following*	*Following*	*Following*

MerCruiser II-TR Transmission Model A Malfunctions

NOTE: Refer to Section 6E for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in Neutral

Output shaft drags excessively in forward rotation	Electric control box and shift motor not working properly	Repair electric shift (Sec. 7C)
	Forward clutch pack improperly assembled	Remove transmission and reassemble forward clutch pack, using correct procedure
	Damaged or broken forward clutch return spring	Remove transmission and replace forward clutch return spring
	Damaged clutch plates	Remove transmission and replace clutch plate
Output shaft drags excessively in reverse rotation	Reverse clutch lever not free	Check and repair as needed
	Incorrect reverse band adjustment	Readjust, using correct procedure
	Improperly assembled reverse clutch band assembly	Remove transmission and reinstall reverse clutch band assembly

MerCruiser II-TR Transmission Model A Malfunctions

NOTE: Refer to Section 6E for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in Forward

Low oil pressure	Low oil level	Add oil to proper level
	Dirty oil screen	Remove transmission, clean or replace oil screen. Fill transmission with clean oil
	Worn or misaligned output sleeve in transmission housing	Remove transmission and replace output sleeve. Align sleeve as outlined
	Worn or damaged teflon seal rings	Remove transmission and replace teflon seal rings
	Worn or broken oil pump	Remove transmission and replace oil pump
	External or internal oil leak	Refer to subhead "Internal and External Leaks" of this chart, following
	Relief valve stuck	Remove transmission. Remove pump housing and clean valve assembly
Forward clutch engages improperly	Electric shift motor or control box not working properly	Repair electric shift (Sec. 7C)
	Control valve assembled incorrectly	Reassemble control valve, using correct procedure
	Worn or misaligned output sleeve in transmission housing	Remove transmission and replace output sleeve
	Worn or damaged clutch piston oil seals	Remove transmission and replace oil seals
	Worn or damaged teflon seal rings	Remove transmission and replace oil seals
	Forward clutch pack improperly assembled	Remove transmission and reassemble forward clutch pack, using correct procedure
	Damaged or broken forward clutch return spring	Remove transmission and replace forward clutch return spring

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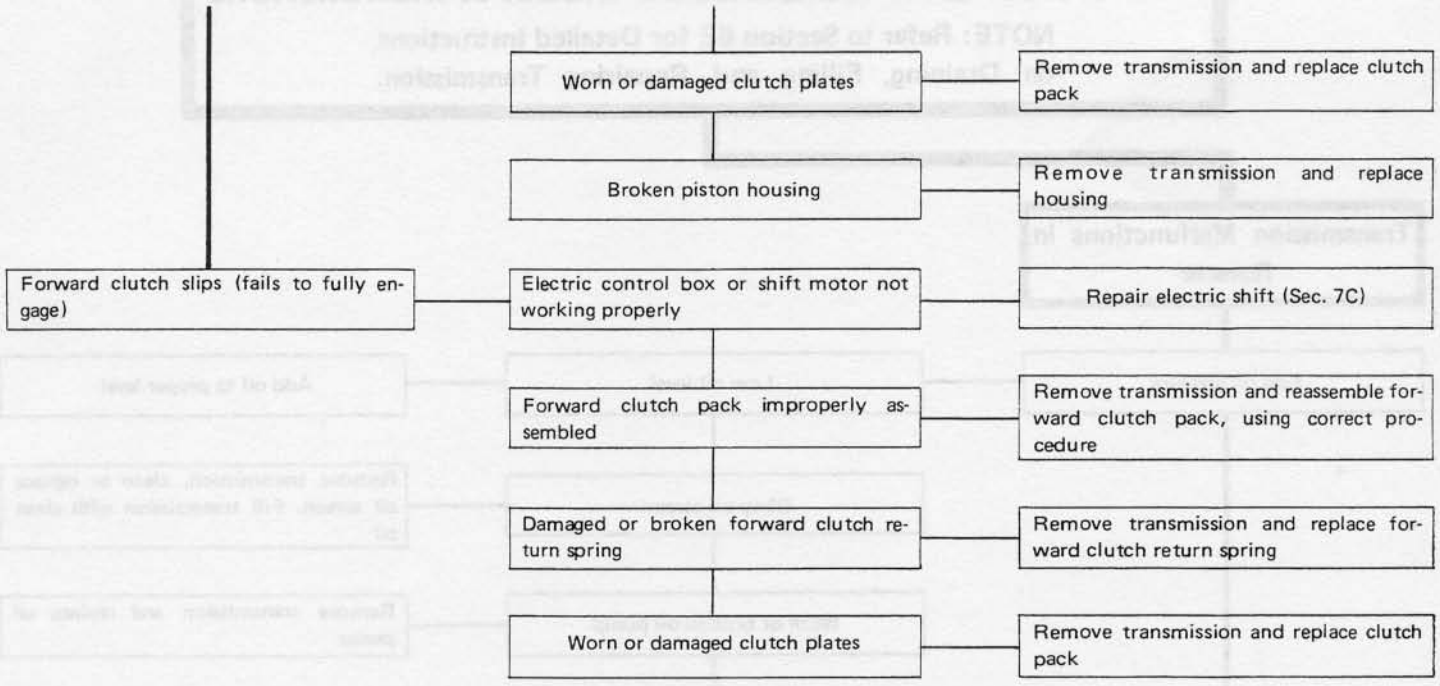

MerCruiser II-TR Transmission Model A Malfunctions

NOTE: Refer to Section 6E for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in Reverse

Low oil pressure	Low oil level	Add oil to proper level
	Dirty oil screen	Remove transmission, clean or replace oil screen. Fill transmission with clean oil
	Worn or broken oil pump	Remove transmission and replace oil pump
	External or internal oil leak	Refer to subhead "Internal and External Leaks" of this chart, following
	Relief valve stuck	Remove transmission. Remove pump housing and clean valve assembly
Reverse clutch engages improperly	Electric control box and shift motor not working properly	Repair electric shift (Sec. 7C)
	Incorrect reverse band adjustment	Adjust reverse band, using correct procedure **NOTE: If band will not adjust, check to see if link is out of place**
	Control valve assembled incorrectly	Reassemble control valve, using correct procedure
	External or internal oil leak	Refer to subhead "Internal and External Leaks" of this chart, following
	Worn or damaged reverse band	Remove transmission and replace reverse band
	Improperly assembled reverse clutch band assembly	Remove transmission and reinstall reverse clutch band assembly
	Planetary gear failure	Remove transmission and replace planetary gear assembly

MerCruiser II-TR Transmission Model A Malfunctions

NOTE: Refer to Section 6E for Detailed Instructions on Draining, Filling and Repairing Transmission.

Transmission Malfunctions in All Ranges

No oil pressure	No oil or oil level very low	Add oil to proper level and determine cause of oil loss. Run engine and check for possible transmission damage
	Broken pump	Remove transmission and remove and replace pump
	Sheared pump drive key	Remove transmission and replace pump drive key
	Relief valve stuck	Remove transmission and replace relief valve
Low oil pressure	Low oil level	Add oil to proper level
	Dirty oil screen	Remove transmission and clean or replace oil screen
	Worn oil pump	Remove transmission and replace oil pump
	Relief valve stuck	Remove transmission. Remove pump housing and clean valve assembly
High oil temperature	Oil level very low	Add oil to proper level and determine cause of oil loss. Run engine and check for possible transmission damage
	Dirty oil cooler or blocked oil line	Clean or replace parts
Does not shift	Electric control box and shift motor not working properly	Repair electric shift (Sec. 7C)
	Electric wires from remote control not connected properly or connections are loose	Check connections and repair as needed (Sec. 3E)
	Control valve assembled incorrectly	Reassemble control valve, using correct procedure

MerCruiser II-TR Transmission Model A Malfunctions

NOTE: Refer to Section 6E for Detailed Instructions on Draining, Filling and Repairing Transmission.

Internal and External Leaks

Oil leaks at control valve	Oil passage plugs leaking	Replace plugs, using sealer. Ball plugs must be staked
	Loose bolts	Torque loose bolts to specifications (Sec. 8)
	Damaged "O" rings	Replace control valve "O" rings
	Damaged gasket or foreign material on mating surfaces	Clean mating surfaces and install new gasket
	Porous control valve housing	Replace housing
Oil leaks at pump	Damaged "O" rings	Remove transmission and replace damaged "O" ring
	Loose bolts	Remove transmission and torque loose bolts to specifications (Sec. 8)
	Damaged or worn oil seal	Remove transmission and replace pump oil seal
	Foreign material on mating surfaces	Remove transmission and clean mating surfaces
	Relief valve or oil discharge passage plug leak	Remove transmission and replace leaking plug. Follow installation procedures
	Porous casting	Remove transmission and replace
Oil leaks at output housing	Loose bolts	Torque loose bolts to specifications (Sec. 8)
	Damaged "O" ring	Remove transmission and replace "O" ring
	Damaged oil seal	Remove transmission and replace oil seal

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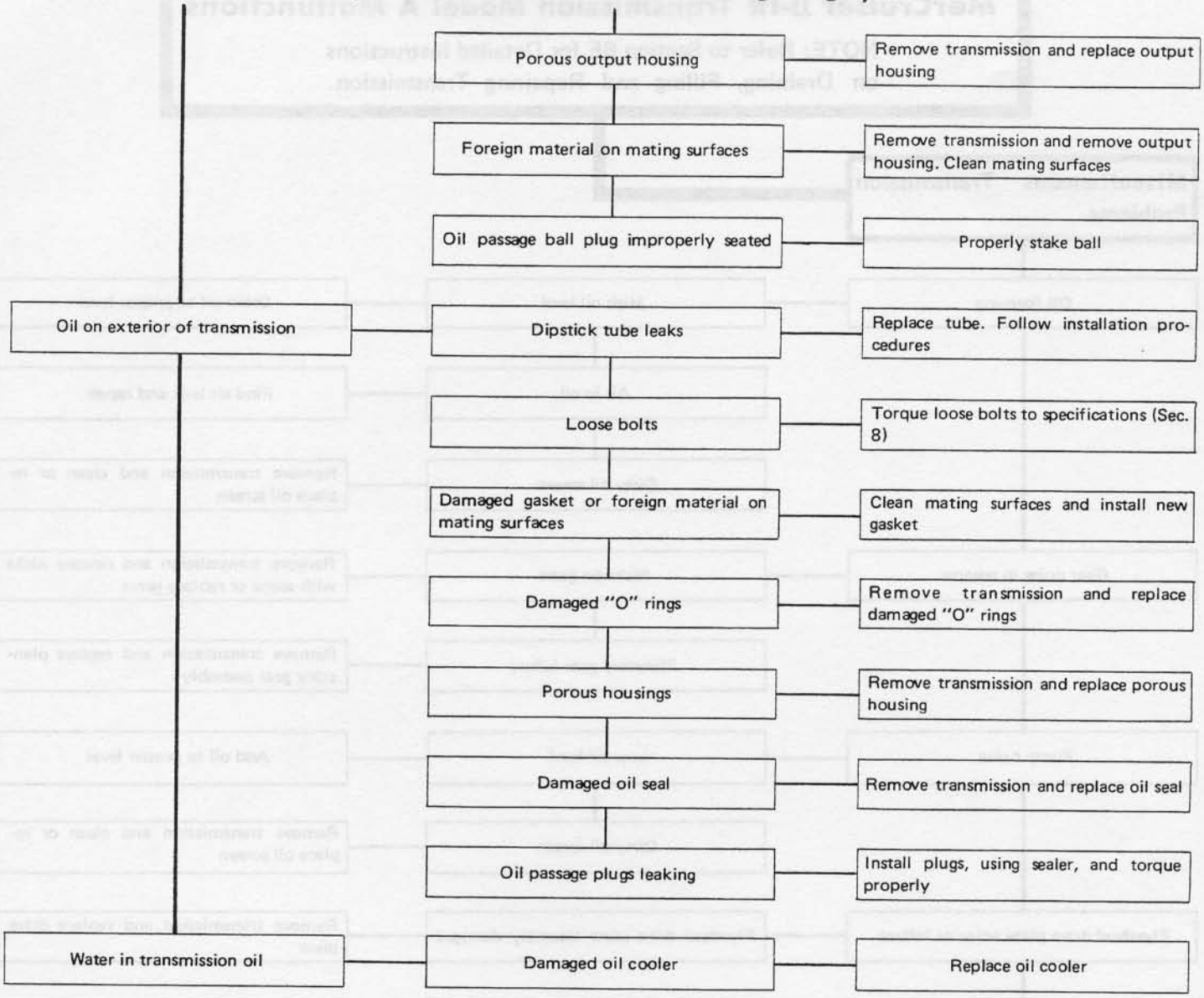

MerCruiser II-TR Transmission Model A Malfunctions

NOTE: Refer to Section 6E for Detailed Instructions on Draining, Filling and Repairing Transmission.

Miscellaneous Transmission Problems

Oil foaming	High oil level	Drain oil to proper level
	Air in oil	Find air leak and repair
	Dirty oil screen	Remove transmission and clean or replace oil screen
Gear noise in reverse	Nicks on gears	Remove transmission and remove nicks with stone or replace gears
	Planetary gear failure	Remove transmission and replace planetary gear assembly
Pump noise	Low oil level	Add oil to proper level
	Dirty oil screen	Remove transmission and clean or replace oil screen
Flywheel drive plate noise or failure	Flywheel drive plate assembly damaged	Remove transmission and replace drive plate
High oil pressure	Wrong oil used in transmission	Change oil, using recommended oil type
	Cold oil (cold temperature operation)	Run engine until it reaches normal operating temperature, then recheck oil pressure
	Relief valve stuck	Remove transmission. Remove pump housing and clean valve assembly
Smoking	Low oil level	Add oil to proper level
	Electric shift motor not working properly	Repair electric shift (Sec. 7C)
	Reverse clutch lever not free	Check and repair
	High rotational speed in reverse	Do not run engine at excess RPM when shifted into reverse gear

Carburetor Malfunctions

For Detailed Information on Disassembly, Inspection, Reassembly and Adjustments, Refer to Section 4B

Flooding	Worn, damaged or dirty needle and seat	Clean or replace needle and seat
	Incorrect float adjustment	Use proper gauge and adjust float to specification
	Leaky or fuel saturated float	Replace and adjust float assembly
	Internal leaky gasket(s)	Replace gasket
Rough idle	Engine idle RPM too low	Adjust engine idle RPM (Sec. 1B)
	Improperly adjusted, worn or damaged idle mixture screws	Replace worn or damaged screws. Adjust idle mixture screws, using proper procedure (Sec. 1B)
	Idle passages dirty	Remove, disassemble and clean carburetor in carburetor cleaner. Install new gaskets
	Throttle valves not closing properly	Check valves for bent condition or not centered. Replace or adjust as needed
	Engine flooding	Refer to "Flooding" of this chart
	Accelerator pump discharge, check valve leaking	Check for out-of-round, damaged seat, stuck or distorted spring. Repair as needed
	Power piston vacuum passage plugged or vacuum leaks	Clean passage and replace gaskets to stop vacuum leak
	Throttle body heat passages plugged with carbon	Remove carburetor and clean heat passages. Install carburetor, using new gasket
Hesitation or acceleration flatness	Accelerator pump inoperative or dirty pump discharge passages	Clean pump discharge passages or repair pump as needed
	Accelerator pump rod out-of-adjustment	Adjust pump rod to specifications

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	Accelerator pump inlet check out-of-round, damaged or stuck	Repair as needed
	Leaking carburetor gaskets	Replace broken, hard or brittle gaskets. Tighten loose screws
	Automatic choke sticking or out-of-adjustment	Clean, repair or adjust as needed
	Power piston or valve dirty, distorted or sticking	Clean or replace as needed
	Throttle valves damaged or sticking	Check and repair as needed
	Throttle body heat passages plugged with carbon	Remove carburetor and clean heat passages. Install carburetor, using new gasket
	Main metering jets loose, plugged or incorrect size	Check and repair as needed
	Incorrect float adjustment	Use proper gauge and adjust float to specifications
Engine surges	Main metering jets loose, plugged or incorrect size	Check and repair as needed
	Leaking carburetor gasket(s)	Replace broken, hard or brittle gaskets. Tighten loose screws
	Incorrect float adjustment or float bent, leaking or saturated with fuel	Replace float, if necessary, and adjust to specifications
	Power piston or valve dirty, distorted or sticking	Clean or replace as needed
	Throttle valves not opening fully. Damaged or sticking throttle valves	Check and repair as needed. Adjust throttle linkage
Low top speed or lack of power	Power piston or valve dirty, distorted or sticking	Clean or replace as needed
	Leak in power piston vacuum passage or passage plugged	Check and repair as needed
	Float adjustment incorrect	Use proper gauge and adjust float to specifications
	Main metering jets loose, partly plugged or incorrect size	Check and repair as needed

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	Leaking carburetor gasket(s)	Replace broken, hard or brittle gaskets. Tighten loose screws
Poor cold engine operation	Engine idle RPM too low	Adjust engine idle RPM (Sec. 1B)
	Improperly adjusted, worn or damaged idle mixture screws	Replace worn or damaged screws. Adjust idle mixture screws, using proper procedure (Sec. 1B)
	Throttle valves not opening fully. Damaged or sticking throttle valves	Check and repair as needed. Adjust throttle linkage
	Incorrect automatic choke adjustment	Adjust to specification
	Automatic choke or choke piston dirty, damaged or sticking	Clean or repair as needed. Check for proper adjustment
	Choke vacuum passage plugged or leaking	Check and repair as needed
	Engine flooding	Refer to "Flooding" of this chart, preceding
Engine stalls	Idle mixture screws worn, damaged or out-of-adjustment	Replace worn or damaged screws and adjust, using correct procedure
	Needle and seat worn, damaged or dirty	Replace needle and seat assembly
	Engine flooding	Refer to "Flooding" of this chart, preceding
	Automatic choke dirty, damaged, sticking or out-of-adjustment	Check, clean, repair or adjust as needed
	Carburetor fuel passages dirty	Clean in carburetor cleaner. Reassemble, using new gaskets
	Accelerator pump malfunctioning	Check and repair as needed
	Leaking gaskets	Replace broken, hard or brittle gaskets. Tighten loose screws
Hard starting	Automatic choke dirty, damaged, sticking or out-of-adjustment	Check, clean, repair or adjust as needed
	Incorrect unloader adjustment	Adjust to specification

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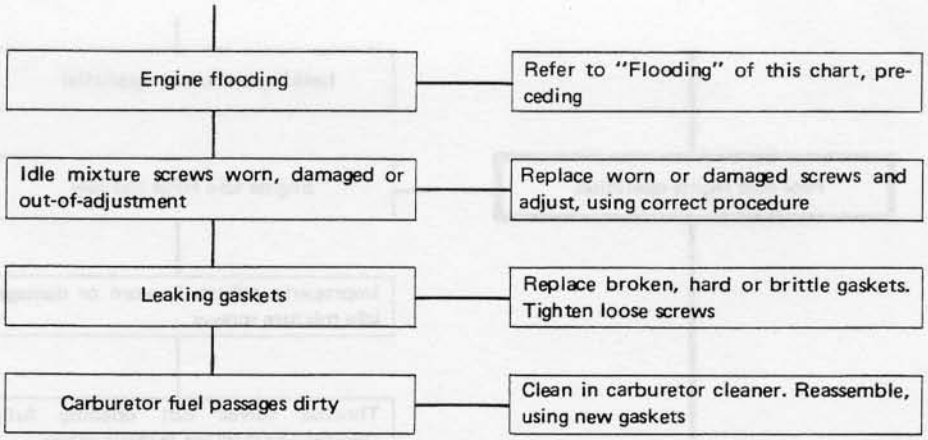

Charging System Inoperative

Alternator Fails to Charge (No Output)

- Drive belt loose or broken — Adjust or replace drive belt (Sec. 3C)
- Engine RPM too low on initial start — On initial start, accelerate engine to 1500 RPM to magnetize rotor field winding
- Electrical wire connection loose or corroded — Inspect connections for corrosion and tighten all loose connections (Sec. 3E)
- Check amperage output of alternator at "BAT" terminal (located at rear of alternator). Run engine at 3000 RPM
  - No Amperage Indicated — Remove, disassemble and test alternator components and regulator. Repair as needed (Sec. 3C)
  - Normal Amperage
- **NOTE: To test alternator for maximum output, refer to "Low or Unsteady Charging Rate" of this chart, right**
- Unacceptable battery condition (will not accept charge) — Check level of electrolyte. Refer to "Storage Battery" (Sec. 3A)
- Inoperative ammeter or battery gauge — Test gauge. Repair as necessary (Sec. 3D)
- Bad wiring to gauge — Test wiring for shorts and continuity (Sec. 3E)

Low or Unsteady Charging Rate

- Drive belt loose or broken — Adjust or replace drive belt (Sec. 3C)
- Electrical wiring connections loose or corroded — Inspect connections for corrosion and tighten all loose connections (Sec. 3E)
- **CAUTION: When using following procedure, extreme care must be taken to keep area well ventilated. Gas vapor buildup is explosive.**
  Check alternator for maximum output. Connect ampere meter in circuit at alternator "BAT" terminal. Remove coil high tension wire from distributor cap and ground wire to engine block. Crank engine approximately 15 seconds to remove battery surface charge. Start engine and run at approximately 3000 RPM. Ampere output should be approximately 30 amps.
  - No or Low Charge — Remove, disassemble and test alternator components and regulator. Repair as needed (Sec. 3C)
  - Normal Charge
- Inoperative ammeter or battery gauge — Test gauge. Repair as necessary (Sec. 3D)
- Bad wiring to gauge — Test wiring for continuity and shorts

Excessive Charging Rate to a Fully Charged Battery (On Next Page)

Noisy Alternator (On Next Page)

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Excessive Charging Rate to a Fully Charged Battery

- Bad voltage regulator
  - Remove and disassemble alternator. Test voltage regulator. Repair as necessary (Sec. 3C)

Noisy Alternator

- Loose mounting bolts — Properly install and tighten alternator mounting bolts
- Worn or frayed drive belt — Install new drive belt and adjust belt tension (Sec. 3C)
- Loose drive pulley — Install properly and tighten drive pulley nut (Secs. 3C and 8)
- Worn or dirty bearings — Remove, clean and repack bearings with Ball Bearing Lubricant (C-92-36204) or replace bearings (Sec. 3C)
- Defective diode trio or stator — Remove, disassemble and test alternator components. (Sec. 3C) Repair as needed

Cranking Circuit Malfunction

Starter Does Not Turn Engine

Autolite and Prestolite Starter Motors

Shift control lever not in neutral position

Make sure that control lever is exactly in "Neutral"

Circuit overload

Reset circuit breaker. If circuit breaker will not remain in reset position, locate and disconnect or correct source of overload

Neutral start safety switch malfunction

Check and repair as needed

Corroded or shorted wiring or loose connections

Visually inspect battery cables and all cranking system wiring for corrosion and loose connections. Also check wiring insulation for signs of overheating due to direct short in system. If short is in wiring, replace wiring. If short is not in wiring, locate and repair. Refer to "Short in System", following

Run down or bad battery

Check condition of battery, using hydrometer (Sec. 3A)
CAUTION: Be sure voltmeter (being used) will withstand full battery voltage.
A fully charged MerCruiser battery will read minimum of 12 volts. Add water (if necessary), recharge or replace battery.

Open or short in cranking system

CAUTION: Be sure voltmeter (being used) will withstand full battery voltage.
Connect voltmeter across battery terminals. Since battery condition has already been checked, voltmeter will read minimum of 12 volts.
CAUTION: When using following procedure, if wiring becomes hot or smoke appears at starter motor or wiring, immediately turn key switch to "Off".
A direct short has been found. Continue with "Short in System", right. Turn key switch to "Start". If battery voltage does not drop, an open exists in system. Continue with "Open in System", right. If battery voltage does drop but starter motor does not crank, a short exists in system, or starter motor is jammed mechanically. Continue with "Short in System", right. Turn key switch off

Short in System

Since battery cables and wiring have been visually inspected or, if smoke was visible in preceding test, shorted component already is located, or it can be assumed that short is in starter motor. Remove starter motor, disassemble, test components and repair as needed. (Sec. 3A) If starter motor is jammed mechanically, remove starter and repair as needed; however, if further checks for locating short are desired, continue with next step

Disconnect wire from starter motor. Momentarily turn key switch to start position. If battery voltage does not drop, starter motor is shorted. If battery voltage still drops, short is external from starter

Use Section 3E "Wiring Diagrams" and voltmeter to check system for opens. Start with voltmeter leads at battery. Keep negative (-) voltmeter lead attached to battery negative (-) terminal. Move voltmeter positive (+) lead along cranking system positive (+) wiring at all connections up to starter solenoid. Keep positive (+) voltmeter lead attached to starter solenoid and move meter negative (-) lead to engine block (common ground) starter case, starter terminal and opposite side of starter solenoid. Without energizing solenoid, voltmeter should read battery voltage at each point. If not, a faulty connection or component has been located. Repair poor connection and replace faulty wiring. If starter motor has open circuit, remove starter, disassemble and test starter motor components. Repair as needed

Open in System

With volt leads connected across large terminals of starter solenoid, voltmeter will read battery voltage, since all other components already have been checked. Turn key switch to "Start" to energize voltage. Voltmeter reading should drop to near zero

If voltage does not drop to near zero, solenoid is bad, or it is not being energized. This can be checked by connecting voltmeter between engine ground and small solenoid terminal with yellow or yellow/black wire attached. Voltmeter should read battery voltage with key switch in "Start". If battery voltage is present, but solenoid does not energize, solenoid is bad and needs replacement. If no battery voltage is present, problem is in key switch circuit, or solenoid is not grounded properly. Test for continuity between solenoid mounting bracket and engine ground. Meter should show full continuity. If not, check for paint at solenoid mounting surfaces. If continuity meter shows full continuity, but solenoid does not energize, test key switch as outlined in Section 3D

Cranking Circuit Malfunction

Delco Remy Starter Motor

Starter Does Not Turn Engine

Shift control lever not in neutral position
Make sure that control lever is exactly in "Neutral"

Circuit overload
Reset circuit breaker. If circuit breaker will not remain in reset position, locate and disconnect for correct source of overload

Neutral start safety switch malfunction
Check and repair as needed

Corroded or shorted wiring or loose connections
Visually inspect battery cables and all cranking system wiring for corrosion and loose connections. Also check wiring insulation for signs of overheating due to direct short in system. If short is in wiring, replace wiring. If short is not in wiring, locate and repair. Refer to "Short in System", right

Run down or bad battery
Check condition of battery, using hydrometer (Sec. 3A)
CAUTION: Be sure voltmeter (being used) will withstand full battery voltage.
A fully charged MerCruiser battery will read minimum of 12 volts. Add water (if necessary), recharge or replace battery

Open or short in cranking system
CAUTION: Be sure voltmeter (being used) will withstand full battery voltage.
Connect voltmeter across battery terminals. Since battery condition already has been checked, voltmeter will read minimum of 12 volts.
CAUTION: When using following procedure, if wiring becomes hot or smoke appears at starter motor or wiring, immediately turn key switch to "Off".
A direct short has been found. Continue with "Short in System", right. Turn key switch to "Start". If battery voltage does not drop, an opening exists in system. Continue with "Open in System", right. If battery voltage does drop, but starter motor does not crank, a short exists in system or starter motor is jammed mechanically. Continue with "Short in System", right. Turn key switch off

Short in System

Since battery cables and wiring have been visually inspected or, if smoke is visible in preceding test, shorted component already is located, or it can be assumed that short is in starter motor. Remove starter motor, disassemble, test components and repair as needed. (Sec. 3A) If starter motor is jammed mechanically, remove starter and repair as needed; however, if further checks for locating short are desired, continue with next step

Remove and insulate starter field winding strap from starter solenoid lower large terminal. Momentarily turn key switch to start position. If battery voltage does not drop, starter motor is shorted. If battery voltage still drops, short is external from starter

Use Section 3 "Wiring Diagrams" and voltmeter to check system for opens. Start with voltmeter leads at battery. Keep negative (-) voltmeter lead attached to battery negative (-) terminal. Move voltmeter positive (+) lead along cranking system positive (+) wiring at all connections up to starter slave solenoid (solenoid not attached to starter motor). Keep positive (+) voltmeter lead attached to starter slave solenoid and move meter negative (-) lead to engine block, (common ground) starter case, starter field winding straps (connected to starter solenoid lower large terminal), starter solenoid terminal with yellow or yellow/black wire attached, then to opposite side of starter solenoid. Without energizing solenoid(s), voltmeter should read battery voltage at each point. If not, a faulty connection or component has been located. Repair poor connection and replace faulty wiring or starter solenoid. If starter motor has open circuit, remove starter, disassemble and test starter motor components. Repair as needed

With voltmeter connected across large terminals of starter slave solenoid, voltmeter will read battery voltage. Turn key switch to "Start" to energize voltage. Voltmeter reading should drop to near zero. Turn key switch off

If voltage does not drop to near zero, slave solenoid is bad, or it is not being energized. Check by connecting voltmeter between engine ground and small solenoid terminal with yellow or yellow/black wire attached. Voltmeter should read battery voltage with key switch in "Start". If solenoid energizes, solenoid and key switch circuit is good. Continue to next step. If battery voltage is present, but solenoid does not energize, solenoid is bad and needs replacement. If no battery voltage is present, problem is in key switch circuit, or solenoid is not grounded properly. Test solenoid ground wire (black wire attached to solenoid small terminal) for continuity. Meter should show full continuity. If not, replace wire. If continuity meter shows full continuity, but slave solenoid does not energize, test key switch as outlined in Section 3D

Open in System

If slave solenoid tests good, but starter does not crank, an additional test may be performed on starter solenoid (solenoid mounted on starter). Connect voltmeter across large terminals of starter solenoid. Voltmeter will read battery voltage, since all other components already have been checked. Turn key switch to "Start" to energize voltage. Voltmeter reading should drop to near zero.

If voltage does not drop to near zero, starter solenoid is bad, or it is not being energized. This can be checked by connecting voltmeter between engine ground and small solenoid terminal with yellow or yellow/black wire attached. Voltmeter should read battery voltage with key switch in "Start". If battery voltage is present, but solenoid does not energize, solenoid is bad and needs replacement

Instrument Malfunction

Check for battery voltage

Observe gauge light bulb. If bulb lights with key switch in "Run" position, voltage is being supplied to gauge and gauge is grounded properly.
CAUTION: It is possible that bulb could be burned out. Voltage also may be checked with voltmeter. Connect voltmeter between gauge terminal (with white wire attached) and gauge case

No Voltage

Corroded wiring connections

Check condition of battery

Test key switch (Sec. 3D)

Voltage Present

Test gauge (Sec. 3D)

Gauge Test Bad

Replace gauge (Secs. 3D and 3E)

Gauge Test Good

Test sender (Sec. 3D)

Sender Test Bad

Replace sender (Sec. 3D)

Sender Test Good

Check wiring between gauge and sender. Remove and insulate wire from sender. Turn key switch to "Run" position. Observe gauge indicator position. Indicator should deflect to one end of gauge scale. Turn key switch to "Off" position. Ground sender wire (end near sender) to common ground. Turn key switch to "Run" position. Gauge indicator should deflect to opposite end of gauge scale. If not, replace wiring between gauge and sender.

USED SPARK PLUG ANALYSIS

Use the following illustrations to help reach a decision that plug is or is not serviceable and can be restored by cleaning, filing and regapping. Spark plug condition also can suggest a variety of possible engine malfunctions and, therefore, can indicate needed engine repairs. When old plugs are replaced, entire set should be replaced. Plug service should be performed only on those plugs suitable for additional service, using the following procedures:

- **Remove any oil deposits with solvent and dry plugs thoroughly.**
- **Open electrode gap wide enough to permit cleaning and filing.**
- **Remove combustion deposits and all abrasive material remaining on plug thread and bore surfaces, then clean with compressed air.**
- **File electrode surfaces to restore clean, sharp edges. Again remove filings with compressed air.**
- **Reset gap to specifications by bending only side electrode with proper tool.**

PLUG ANALYSIS

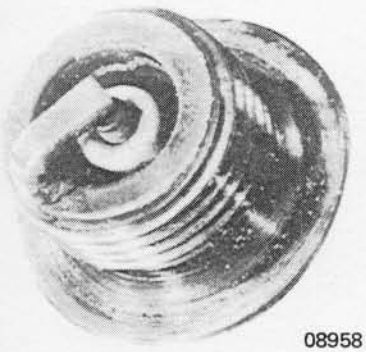

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Figure 1.
Normal Condition

NORMAL CONDITION (Figure 1)

Few deposits are present and probably will be light tan or gray in color. This plug shows that plug heat range is compatible with engine, and engine is electrically and mechanically in good running condition. With proper plug servicing (clean, file and regap), this plug can be reinstalled with good results.

CHIPPED INSULATOR (Figure 2)

Chipped insulator usually results from careless plug regapping. Under certain conditions, severe detonation also can split insulator firing ends. Plug must be replaced.

Figure 2.
Chipped Insulator

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WET FOULING (OIL DEPOSITS) (Figure 3)

Plug becomes shorted by excessive oil entering combustion chamber, usually in engine with many hours of operation. Worn piston rings, cylinder walls, valve guides or valve stem seals are causes of oil entering combustion chamber. Only engine repairs will permanently relieve oil wet fouling.

CAUTION: New engines or recently overhauled engines may wet foul plugs before normal oil control is achieved with proper break-in procedures. Such fouled plugs may be serviced (clean, file and regap) and reinstalled.

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Figure 3. Wet Fouling (Oil Deposits)

COLD FOULING (Figure 4)

Dry, black deposits indicate rich fuel mixture or weak ignition. Clogged flame arrestor, flooding carburetor, sticky choke or weak ignition components all are probable causes. If only one or two plugs in set are fouled, however, check for sticking valves or bad ignition leads. After correcting cause, service (clean, file and regap) plugs and reinstall.

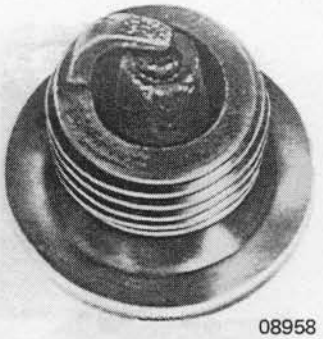

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Figure 4.
Cold Fouling

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Figure 5.
Overheating

OVERHEATING (Figure 5)

Insulator is dull white or gray and appears blistered. Electrodes are eroded and there is an absence of deposits. Check that correct plug heat range is being used. (Sec. 8) Also check over-advanced ignition timing, cooling system malfunction, lean fuel/air mixtures, leaking intake manifold or sticking valves. Replace spark plugs.

HIGH SPEED GLAZING (Figure 6)

Insulator has yellowish, varnish-like color, indicating that temperatures suddenly have risen, usually during hard, fast acceleration under heavy load. Normal deposits do not get a chance to blow off. Instead, they melt and form a conductive coating. Replace plugs. If condition re-occurs, use colder heat range plug and service plugs more frequently.

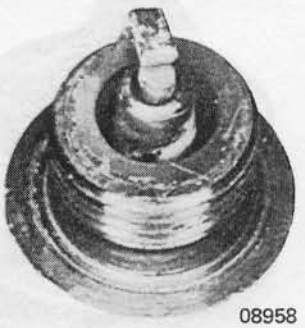

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Figure 6.
High Speed Glazing

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Figure 7.
Scavenger Deposits

SCAVENGER DEPOSITS (Figure 7)

Powdery white or yellow deposits are built up on shell, insulator and electrodes. This is normal appearance with certain branded fuels. Accumulation on ground electrode and shell areas may be unusually heavy, but may be easily chipped off. Plugs can be serviced (clean, file and regap) and reinstalled.

PRE-IGNITION DAMAGE (Figure 8)

Pre-ignition damage is caused by excessive high temperatures. Center electrode melts first, followed by ground electrode. Normally, insulators are white but may be dirty if plug has been misfiring. Check for correct plug heat range, advanced ignition timing, lean fuel mixture, incorrect fuel used, malfunctioning cooling system, leaking intake manifold or lack of lubrication.

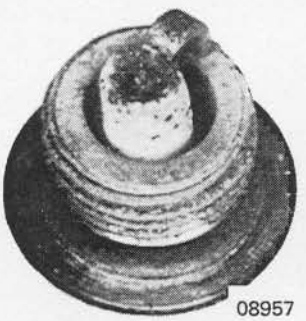

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Figure 8.
Pre-Ignition Damage

REVERSED COIL POLARITY (Figure 9)

Concave erosion of ground electrode is an indication of reversed polarity. Center electrode will show only normal wear. Engine will misfire and idle rough. To correct, reverse primary coil leads (Sec. 3E). Replace spark plugs.

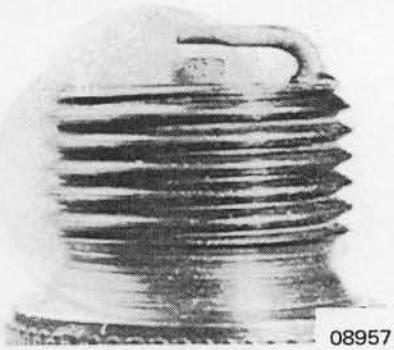

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Figure 9.
Reversed Coil Polarity

SPLASHED DEPOSITS (Figure 10)

Spotted deposits, which sometimes occur after long delayed tune-up, accumulate after a long period of misfiring. When normal combustion temperatures are restored, upon installation of new plugs, deposits loosen from top of piston and head and are thrown against hot insulator. Clean and service plugs and reinstall.

Figure 10.
Splashed Deposits

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MECHANICAL DAMAGE (Figure 11)

Mechanical damage to spark plug firing end is caused by foreign object in combustion chamber. Because of valve overlap, small objects can travel from one cylinder to another. Check all cylinders, intake manifold and exhaust manifold to prevent further damage.

NOTE: When working on engine, spark plug holes and carburetor throat should be kept covered to prevent foreign objects from entering combustion chamber.

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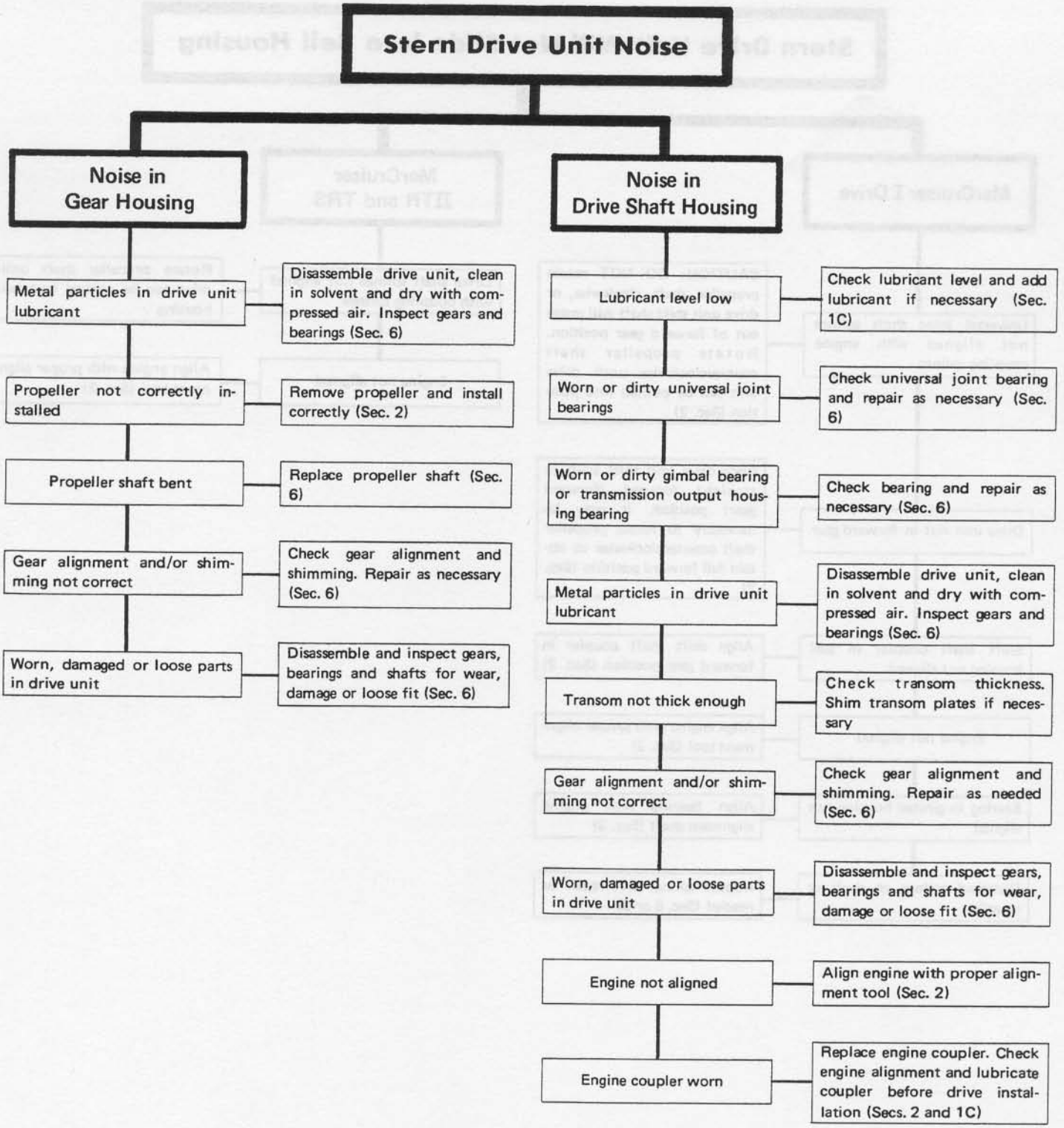
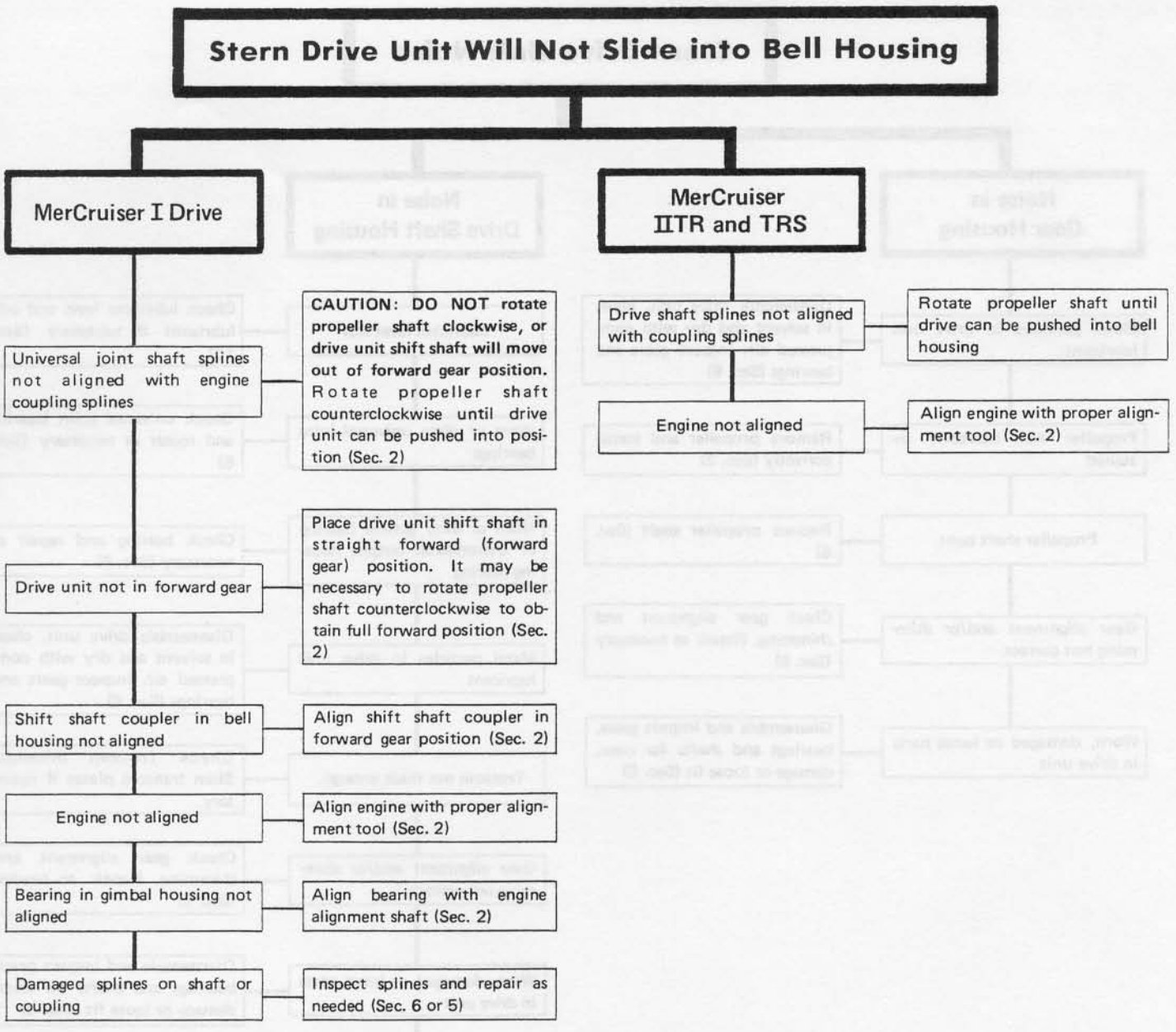
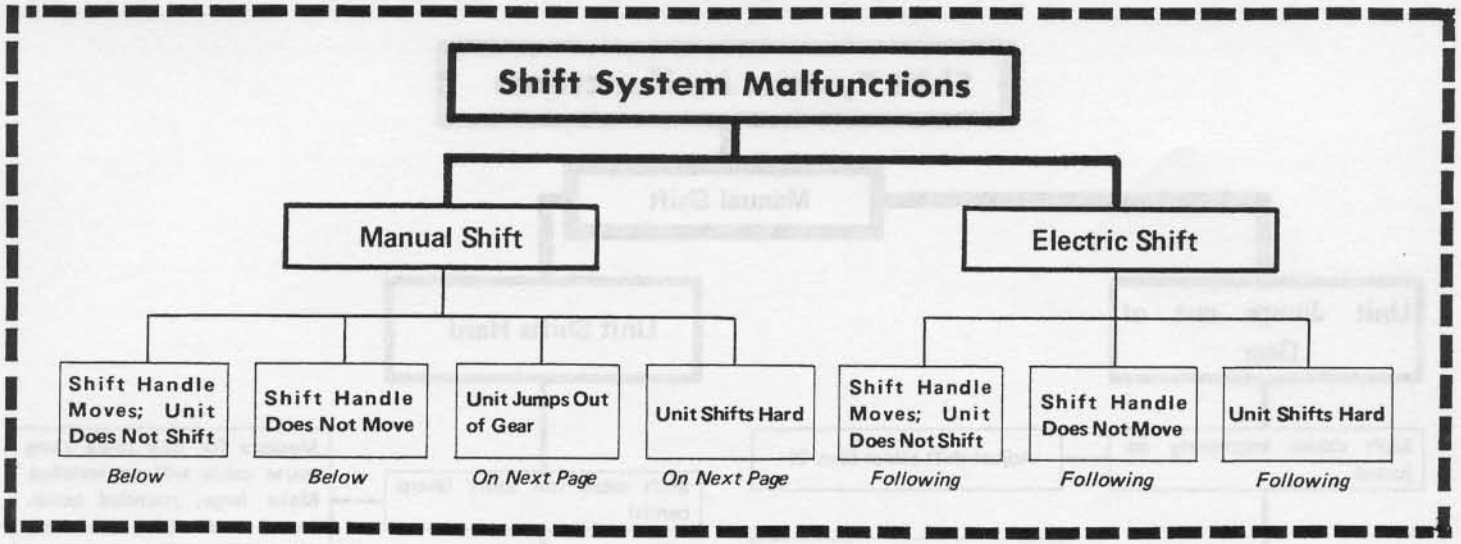
Figure 11.
Mechanical Damage

Stern Drive Unit Noise



Stern Drive Unit Will Not Slide into Bell Housing





Shift System Malfunctions

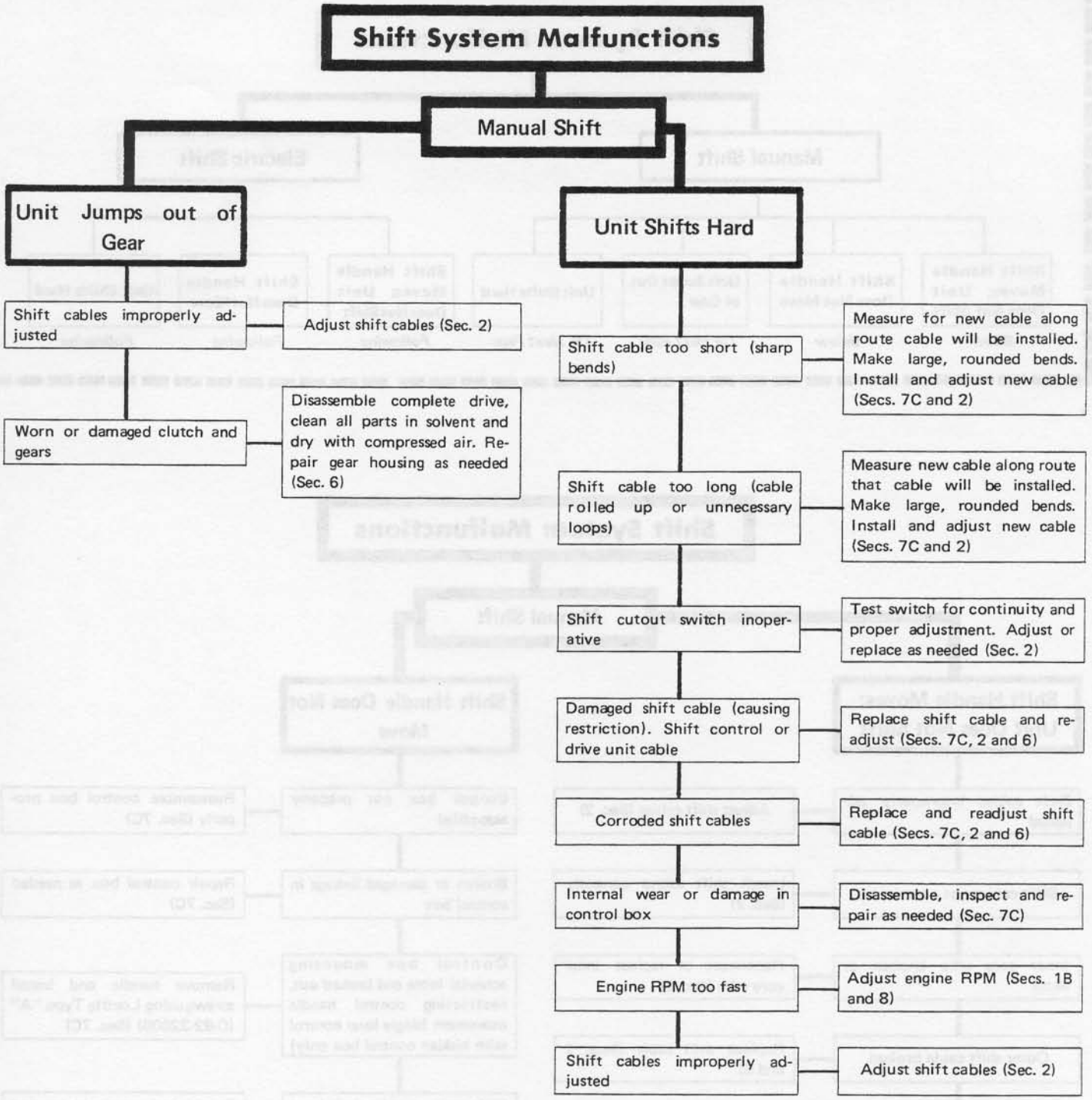
Manual Shift

Shift Handle Moves; Unit Does Not Shift

Shift cables improperly adjusted	Adjust shift cables (Sec. 2)
Shift cables not connected	Install shift cables correctly (Sec. 2)
Inner core wire broken or loose	Reconnect or replace inner core wire (Sec. 6)
Outer shift cable broken	Replace shift cable (Secs. 2 and 6)
Shift crank (located in gear housing) improperly installed (I drive only)	Install shift crank properly (Sec. 6)
Broken shift shaft coupler (located in bell housing)	Replace shift shaft assembly (Sec. 6)

Shift Handle Does Not Move

Control box not properly assembled	Reassemble control box properly (Sec. 7C)
Broken or damaged linkage in control box	Repair control box as needed (Sec. 7C)
Control box mounting screw(s) loose and backed out, restricting control handle movement (single lever control with hidden control box only)	Remove handle and install screws, using Loctite Type "A" (C-92-32609) (Sec. 7C)
Shift shaft or shift shaft lever jammed	Check and repair as needed (Sec. 6)
Controls improperly adjusted (cable end guide hitting brass barrel)	Adjust shift cables (Sec. 2)


Shift System Malfunctions
Manual Shift
Unit Jumps out of Gear
Unit Shifts Hard
Shift cables improperly adjusted
Adjust shift cables (Sec. 2)
Worn or damaged clutch and gears
Disassemble complete drive, clean all parts in solvent and dry with compressed air. Repair gear housing as needed (Sec. 6)
Shift cable too short (sharp bends)
Measure for new cable along route cable will be installed. Make large, rounded bends. Install and adjust new cable (Secs. 7C and 2)
Shift cable too long (cable rolled up or unnecessary loops)
Measure new cable along route that cable will be installed. Make large, rounded bends. Install and adjust new cable (Secs. 7C and 2)
Shift cutout switch inoperative
Test switch for continuity and proper adjustment. Adjust or replace as needed (Sec. 2)
Damaged shift cable (causing restriction). Shift control or drive unit cable
Replace shift cable and readjust (Secs. 7C, 2 and 6)
Corroded shift cables
Replace and readjust shift cable (Secs. 7C, 2 and 6)
Internal wear or damage in control box
Disassemble, inspect and repair as needed (Sec. 7C)
Engine RPM too fast
Adjust engine RPM (Secs. 1B and 8)
Shift cables improperly adjusted
Adjust shift cables (Sec. 2)

Shift System Malfunctions

Electric Shift

Shift Handle Moves; Unit Does Not Shift

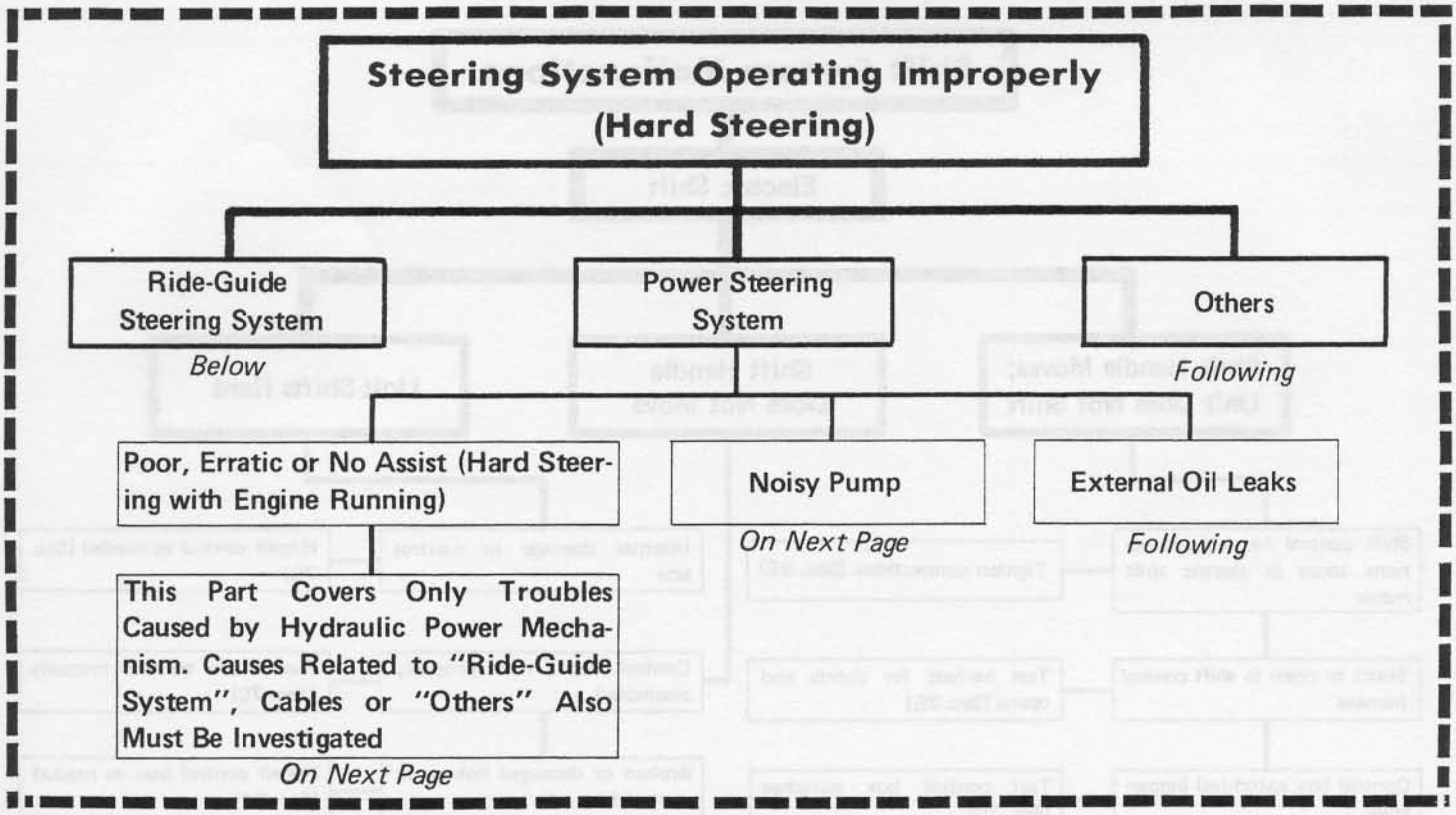
- Shift control harness connections loose at electric shift motor — Tighten connections (Sec. 3E)
- Short or open in shift control harness — Test harness for shorts and opens (Sec. 3E)
- Control box switch(es) inoperative — Test control box switches (Sec. 7C)
- Electric shift motor inoperative — Repair shift motor as needed (Sec. 7C)
- Transmission inoperative (II-TR only) — Check and repair transmission as needed (Sec. 6E)
- Drive unit shift mechanism inoperative (I drive only) — Check and repair drive as needed (Sec. 6)
- Electric shift motor not grounded — Check and repair connections as needed
- Low battery voltage (engine not running) — Recharge or replace battery as needed
- Shift link improperly adjusted (I drive only) — Adjust shift link (see installation sheet)

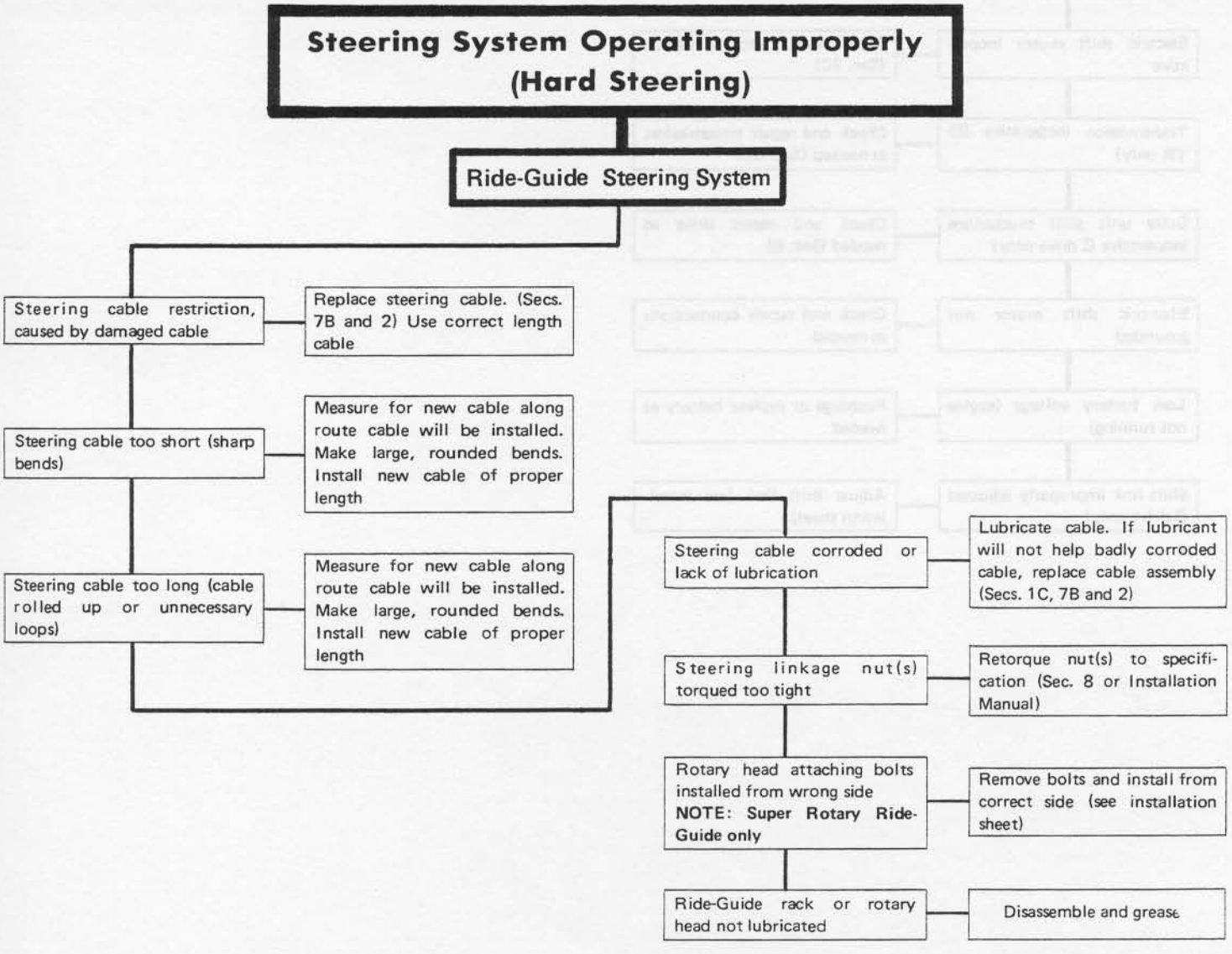
Shift Handle Does Not Move

- Control box not properly assembled — Reassemble control properly (Sec. 7C)
- Broken or damaged linkage in control box — Repair control box as needed (Sec. 7C)

Unit Shifts Hard

- Internal damage in control box — Repair control as needed (Sec. 7C)


Steering System Operating Improperly (Hard Steering)
Ride-Guide Steering System
Below
Power Steering System
Others
Following
Poor, Erratic or No Assist (Hard Steering with Engine Running)
Noisy Pump
On Next Page
External Oil Leaks
Following
This Part Covers Only Troubles Caused by Hydraulic Power Mechanism. Causes Related to "Ride-Guide System", Cables or "Others" Also Must Be Investigated
On Next Page


Steering System Operating Improperly (Hard Steering)
Ride-Guide Steering System
Steering cable restriction, caused by damaged cable
Replace steering cable. (Secs. 7B and 2) Use correct length cable
Steering cable too short (sharp bends)
Measure for new cable along route cable will be installed. Make large, rounded bends. Install new cable of proper length
Steering cable too long (cable rolled up or unnecessary loops)
Measure for new cable along route cable will be installed. Make large, rounded bends. Install new cable of proper length
Steering cable corroded or lack of lubrication
Lubricate cable. If lubricant will not help badly corroded cable, replace cable assembly (Secs. 1C, 7B and 2)
Steering linkage nut(s) torqued too tight
Retorque nut(s) to specification (Sec. 8 or Installation Manual)
Rotary head attaching bolts installed from wrong side
NOTE: Super Rotary Ride-Guide only
Remove bolts and install from correct side (see installation sheet)
Ride-Guide rack or rotary head not lubricated
Disassemble and grease

Steering System Operating Improperly (Hard Steering)

Poor, Erratic or No Assist (Hard Steering with Engine Running)

Power Steering System

This Part Covers Only Troubles Caused by Hydraulic Power Mechanism. Causes Related to "Ride-Guide Steering System", Cables or "Others" Also Must Be Investigated

Loose drive belt	Adjust belt tension (Sec. 7B)
Low oil level	Fill reservoir to proper level (Sec. 7B)
Air in system	Locate source of air in oil return lines or fittings and correct
Leaking hoses	Replace hoses
Defective pump	Replace pump (Sec. 7B)
Low oil pressure in steering cylinder caused by restriction in hoses	Check for kinks and foreign object in hoses. Replace hose, if necessary
Pressure loss in cylinder, caused by worn piston ring or scored housing bore	Replace cylinder
Loose fit of spool in valve body or leaky valve body	Replace valve assembly
Control valve not positioned properly	Adjust per installation instructions (Service Bulletin No. 73-12)
Improper control valve balancing	Adjust control valve (Sec. 7B)
Power Steering mounting bracket adjusting screw loose	Turn screw in until it bottoms out on inner transom plate, then tighten locknut

Noisy Pump

Loose belt	Adjust belt tension (Sec. 7B)
Low oil level	Fill reservoir (Sec. 7B)
Air in oil	Locate source of air in oil return lines or fittings and correct
Defective pump	Replace pump (Sec. 7B)
Excessive back-pressure, caused by restriction in oil passages	Locate restriction and correct
Improper adjusted stop nuts	Check and adjust
Cables other than ride-guide being used	See cable manufacturing for adjusting procedures

Steering System Operating Improperly (Hard Steering)

Power Steering System

External Oil Leaks

Loose hose connections	Tighten hose connections
Damaged hose	Replace hose
Oil leaking at top of reservoir (too full)	Remove oil down to proper level
Oil leaking at top of reservoir, caused by air or water in oil	Locate source of air or water and correct. Air also may enter system because of low reservoir oil level
Defective pump shaft seal or damaged shaft at seal area	Replace pump
Cylinder piston rod seal	Replace seals (Sec. 7B)
Damaged or worn seals in valve	Replace seals (Sec. 7B)
Cracked or porous metal parts	Locate and repair as needed

Others

Improper trim tab adjustment	Water test boat at speed and trim angle operator generally uses boat. Adjust trim tab as needed (Sec. 1A)
Gimbal ring pivot roller bearings corroded or lack of lubrication	Lubricate bearings. If badly corroded bearings, replace bearings and seals

Power Trim System Malfunctioning

Electrical	Hydraulic *(Following)*	Mechanical *(Following)*
Will not trim up or out	Limit switch open or disconnected	Replace switch or reconnect (Sec. 6)
	Defective push button(s)	Replace defective part(s) (Sec. 3D)
	Defective trim motor solenoid	Replace solenoid
	Defective trim motor field winding ("Up" circuit)	Test and replace if necessary (Sec. 7A)
Will not tilt to full "Up" position	Trailering or "Up" button open circuit	Replace "Up" button (Sec. 3D)
Will trim up or out with drive unit in reverse gear	Improperly adjusted reverse lock valve	Adjust according to procedure (Sec. 2)
	Cutout switch shorted	Replace switch
Pump motor runs intermittently	Open or loose connections	Test and replace defective parts
	Open in armature	Replace armature (Sec. 7A)
Pump motor runs only in "Down" direction	Defective push button(s)	Test and replace defective part(s) (Sec. 3D)
	Cutout switch open or disconnected	Replace switch or reconnect leads
	Solenoid inoperative	Replace solenoid
	Defective field winding ("Up" circuit)	Replace defective part
	High resistance, broken or loose connection(s) in "Up" circuit	Replace defective parts
Pump motor runs only in "Up" direction	Defective push button(s)	Test and replace defective part(s) (Sec. 3D)

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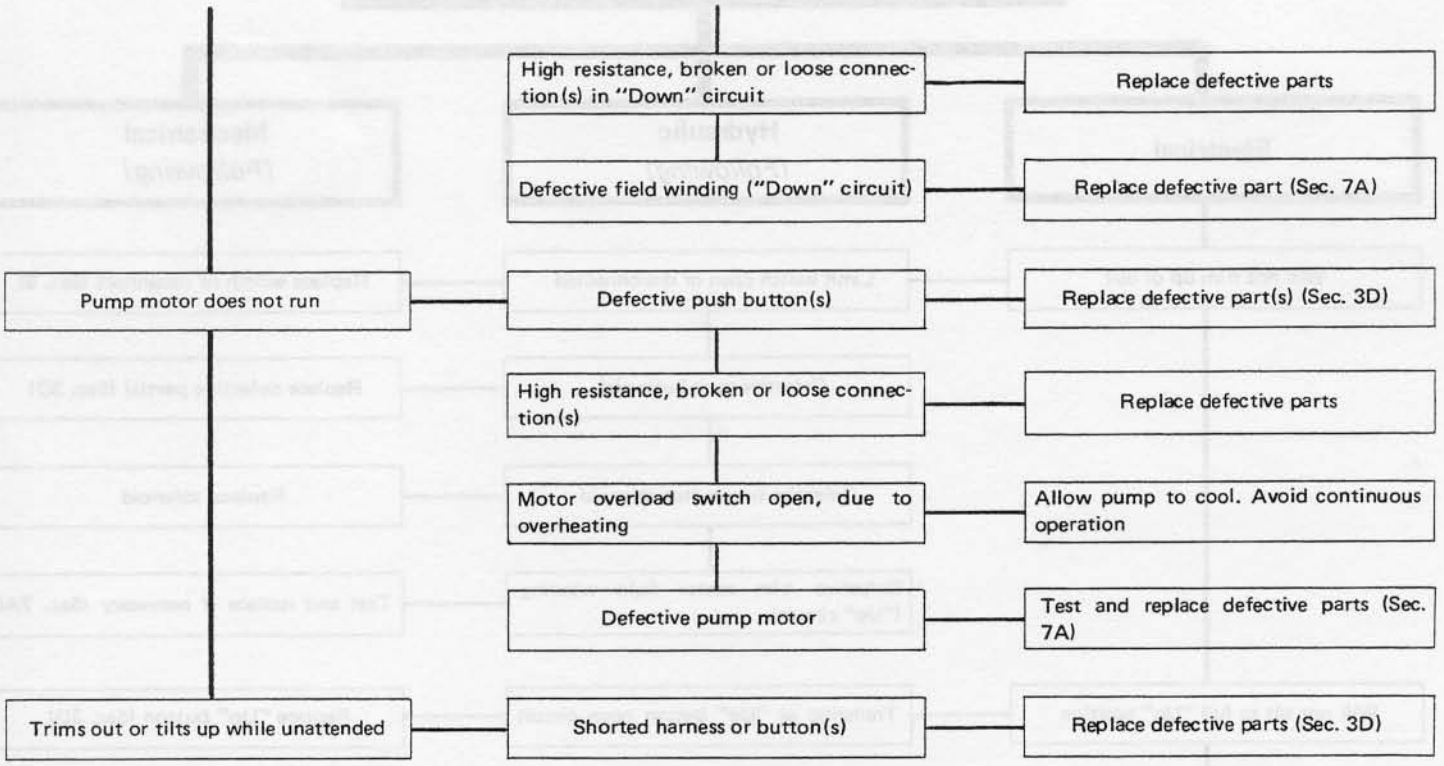

Power Trim System Malfunctioning

Hydraulic

Use Hydraulic Pump Test Gauge Assembly when troubleshooting Power Trim hydraulic system. Refer to Section 9 "Tools" for part number

Will not trim up or out	Oil level low	Add oil (Formula 4-20W), bleed system and check for leaks (Sec. 7A)
	Internal resistance in cylinders	Replace or repair cylinder(s) (Sec. 7A)
	Reverse lock valve not properly adjusted	Adjust valve and/or replace valve (Secs. 7A and 2)
	Too low or no pump pressure	Replace pump valve body assembly (Sec. 7A)
Will not tilt to full "Up" position	Oil level low	Add oil (Formula 4-20W) and bleed system (Sec. 7A)
	Internal resistance in cylinders	Replace or repair cylinder(s) (Sec. 7A)
Will not release from full "Up" position	Valve body assembly inoperative	Replace valve body (Sec. 7A)
	Internal resistance in cylinders	Replace or repair cylinder(s) (Sec. 7A)
	Internal cylinder leak	Repair cylinder (Sec. 7A)
Will not return completely to "Down" position or returns part way with jerky motion	Air in system	Check for leaks, fill reservoir and bleed system (Sec. 7A)
	Internal cylinder(s) leaks	Replace or repair cylinder(s) (Sec. 7A)
	Internal resistance in cylinders	Replace or repair cylinder(s) (Sec. 7A)
	Hoses reversed on one cylinder only	Reinstall to proper connection

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Will not hold in reverse	Internal cylinder leaks	Replace or repair cylinder(s) (Sec. 7A)
	Reverse lock valve inoperative or improperly adjusted	Adjust, repair or replace valve assembly (Secs. 7A and 2)
Out-drive thumps when shifted	Air in system	Check for leaks, fill reservoir and bleed system (Sec. 7A)
	Internal cylinder leaks	Replace or repair cylinder(s) (Sec. 7A)
	Leak in control valve	Replace control valve assembly (Sec. 7A)
	Improperly adjusted reverse lock valve	Adjust reverse lock valve (Sec. 2)
Trails out when backing off throttle at high speed	Control valve assembly inoperative	Replace control valve assembly (Sec. 7A)
	Air in system	Check for leaks, fill reservoir and bleed system (Sec. 7A)
	Internal cylinder leaks	Replace or repair cylinder(s) (Sec. 7A)
Will not hold a trimmed position or will not remain tilted for extended period	External leaks (fittings or parts leak)	Tighten fittings or replace defective part(s)
	Internal cylinder leaks	Replace or repair cylinder(s) (Sec. 7A)
	Pump check valve leak (high pressure)	Try clearing check valve by operating system up-and-down several times when flushing system. If flushing system fails to correct problem, replace pump valve body assembly
Pumps up or out slowly with jerking movements when tilting or trimming	Hoses reversed on one cylinder only	Reinstall to proper connection
	Air in system	Check for leaks, fill reservoir and bleed system
	Internal resistance in cylinders	Replace or repair cylinder(s)
Reverse lock valve and/or trim cylinder broken open or leaking	Improperly adjusted reverse lock valve	Replace or repair reverse lock valve assembly and adjust according to procedure (Sec. 2)

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	Reversed hose installation on control valve body or gimbal housing	Reinstall to proper connection
Oil foams out of pump vent	Contaminated oil	Flush system with clean oil, fill reservoir and bleed system (Sec. 7A)
	Oil level low	Add oil (Formula 4-20W) and bleed system (Sec. 7A)
	"Can" is not properly installed over pump filter screen	Reinstall "can" over pump oil filter screen

Power Trim System Malfunctioning

Mechanical

Will not trim up or out	Improperly adjusted reverse lock valve	Adjust according to procedure (Sec. 2)
	Unit not in "Neutral" or "Forward" gear	Shift drive unit into "Neutral" or "Forward" gear
	Drive housing interference with gimbal ring	Repair or replace
Will not return completely to "Down" position	Drive housing interference with gimbal ring	Repair or replace

POWER TRIM ELECTRICAL SYSTEM

The Power Trim system allows positioning of the angle of the drive unit in relation to the boat bottom, while the boat is underway. The properly trimmed position gives best performance and varies with boat load, speed and water conditions.

SINGLE SOLENOID - EARLY STYLE

A single-solenoid electrical system, typical of many installations, is shown in Figure 1. A 3-button panel control is shown here. For trimming while underway, the bottom "IN" button and the middle "UP/OUT" button are used. When the "IN" button is pressed, it routes current from the red lead through the green lead, which then operates the pump motor in the down direction.

When the "UP/OUT" button is pressed, power from the red lead flows through the purple lead to the trim limit switch (gimbal ring type shown), which normally is a closed circuit. The blue lead then carries the current to the reverse inter-lock switch, which is a closed circuit in forward and neutral gears. In reverse, this switch opens to prevent trimming out while backing up.

From the reverse inter-lock switch, power goes to the solenoid, where it activates the solenoid to supply (thru the large blue lead) the high-amperage current needed for the trim motor to operate in the out (or up) direction. If a solenoid were not used, the high-amperage needed for trimming out against the thrust of the drive unit would require large wires of short length to the Power Trim controls.

When launching or trailering, it is necessary to trim out further than normally permitted by the trim-limit switch, which stops the out movement before the drive unit moves beyond the support guides of the gimbal ring. To bypass the trim-limit switch for trailering or launching, the top "UP" button and middle "UP/OUT" button are pressed simultaneously. The purple lead on the panel carries power through the "UP" switch to the blue lead, which then proceeds to the solenoid.

If the pump motor were made to continue to run after the cylinders are fully extended, the high amperage flow would damage the motor. For this reason, a bi-metal switch is built into the brush lead, which opens the circuit when the temperature of the lead becomes excessive. As the motor cools, the switch will close to permit normal operation.

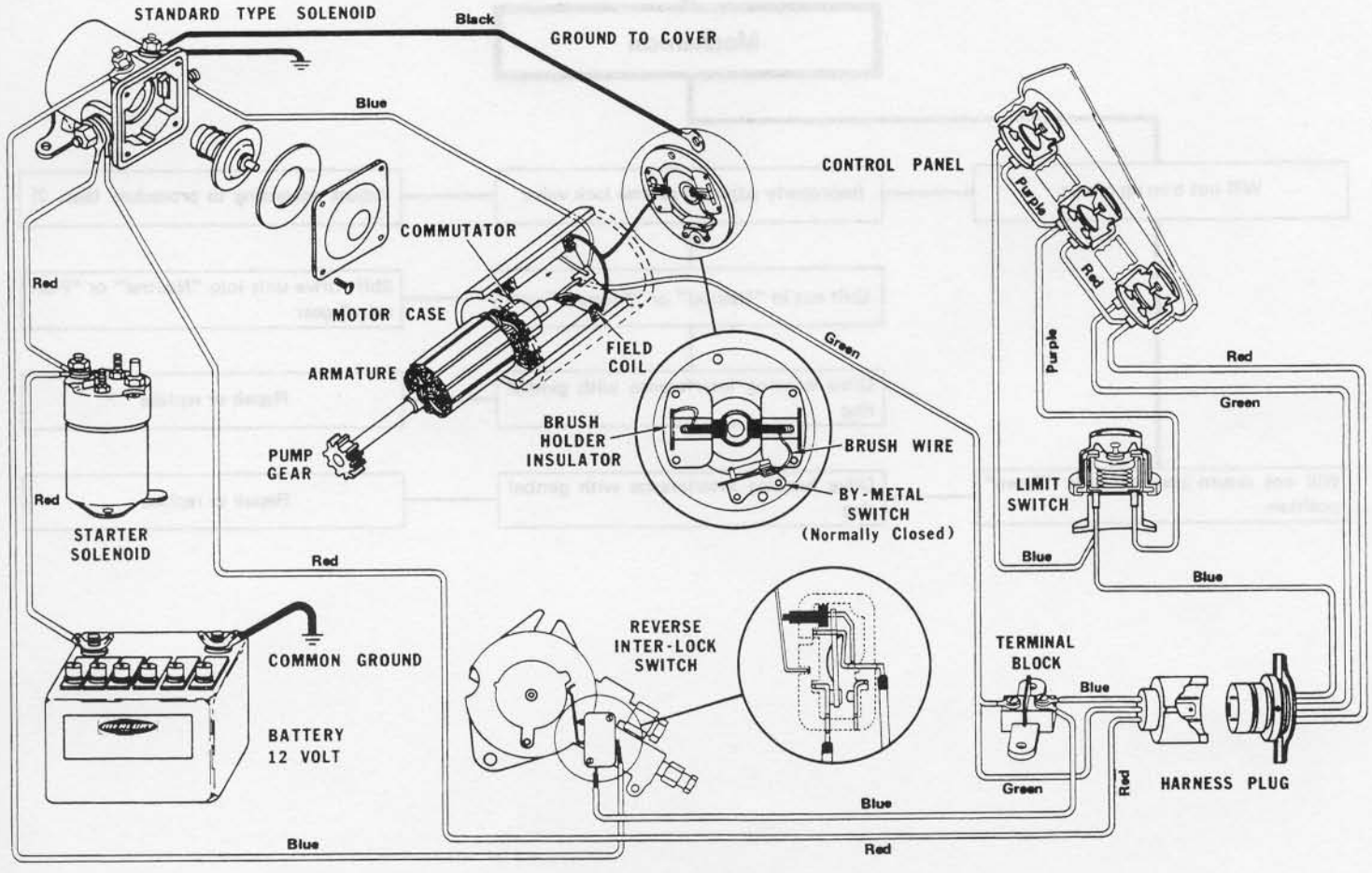


Figure 1. Power Trim Electrical System with 3-Button Control

SINGLE SOLENOID - LATE STYLE

A later version of the Power Trim electrical system is shown in Figure 2. A different type solenoid and a change from a gimbal ring located trim limit switch to one mounted on the bell housing and operated by the hinge pin are differences between this and the earlier system. In addition, a change in the hydraulic system eliminates the need for the reverse inter-lock switch.

Also shown in Figure 2 is the toggle switch type control, which is interchangeable with the 3-button panel, shown in Figure 1. Pressing up on the toggle switch allows power from the red lead to flow through the purple lead to the trim limit switch and on to the solenoid, as previously described. Pressing down on the toggle switch routes power from the red lead to the green lead, thus allowing the pump to operate in the down direction.

The "Trailer" button, next to the toggle switch, operates differently than in the 3-button system in that it is not dependent upon another switch for power. Therefore, for trailering or launching, it is necessary only to press the "Trailer" button.

NOTE: Fuses and circuit breakers are NOT shown in these drawings. Refer to Section 3-E, "Wiring Diagrams", for specific applications.

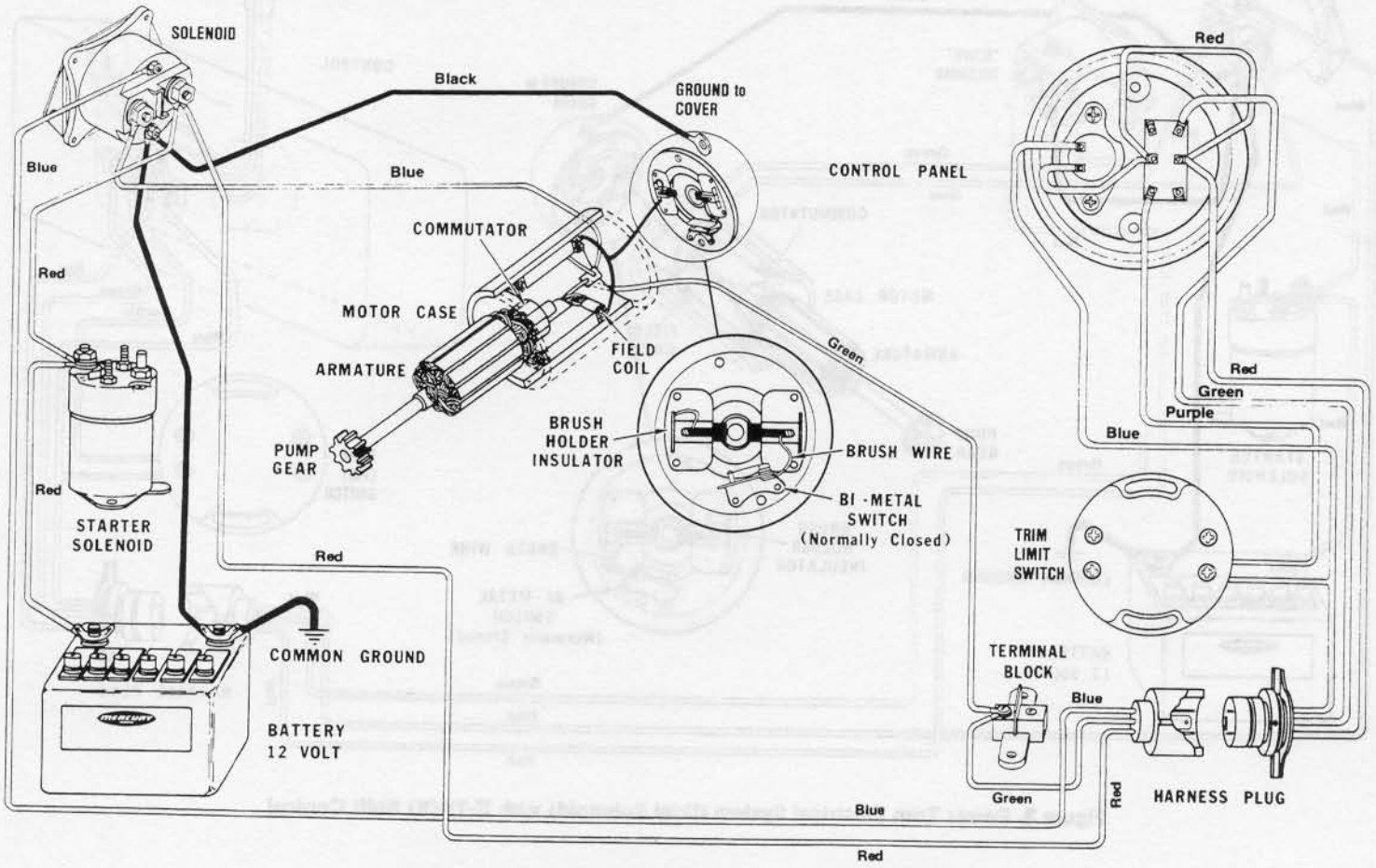


Figure 2. Power Trim Electrical System with Toggle Switch Control

DUAL SOLENOID SYSTEM

Figure 3 shows a late-model two-solenoid system. A second solenoid is employed in the down circuit, in addition to the one in the up circuit, when the large II-Drive or II-TR(S) Drive is used, or when considerable harness length would result in too great a voltage drop for the pump motor to operate properly. In addition, some controls, such as the II-TR Electric Shift model shown, require the use of dual solenoids so that a smaller gauge of wire may be used in the controls.

The top button in the handle passes current from the red lead to the purple lead, which runs to the Trim Limit Switch, then to the blue lead which activates the "up" solenoid. The lower button routes current through the green lead to the "down" solenoid for trimming in. The "Trailer" button (mounted in the control box) operates as indicated in Figure 2.

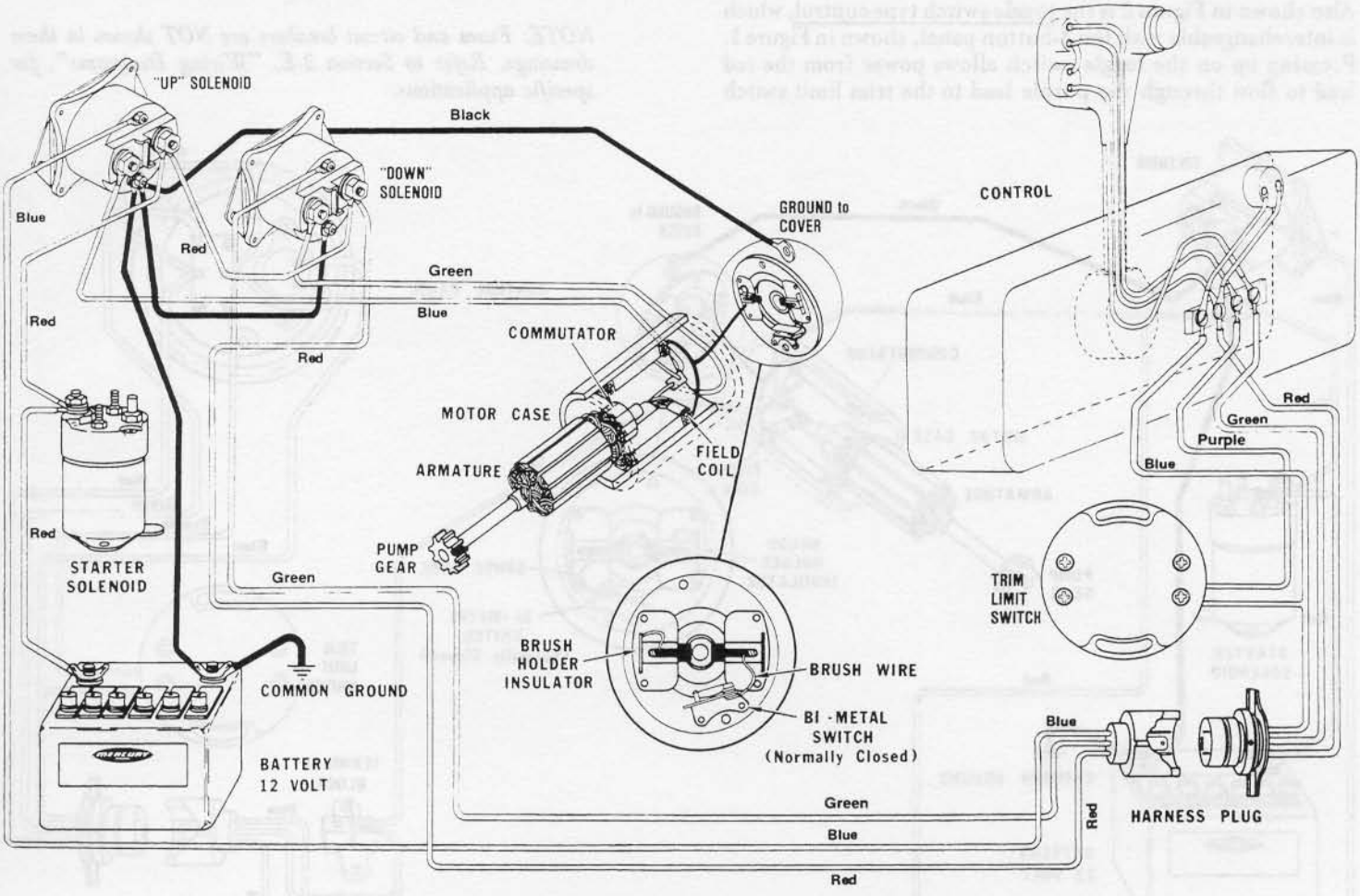


Figure 3. Power Trim Electrical System (Dual Solenoid) with II-TR(S) Shift Control

MERCRUISER POWER TRIM HYDRAULIC CIRCUIT OPERATION

HYDRAULIC "UP" CIRCUIT (Figure 4)

When Power Trim pump is activated in the "up" direction, hydraulic pressure (indicated in dark shaded area) moves slide valve (2) and allows fluid to move through valve (4) and into trim cylinder chambers (3). Here, the pressure created pushes the piston outward. Fluid in the "down" side of system (indicated in light shaded area) is forced out of cylinder and back through hoses, reverse lock valve, trim indicator sender (if unit is equipped with a hydraulic-type sender) and into pump reservoir.

Valve (15) regulates amount of "up" pressure produced by the pump, while valve (13) serves as a backup safety valve to prevent excessive pressure. Valve (4) holds the pressure in the "up" system while pump is not running.

The reverse lock valve, used on II-TR and II-TRS units, also is shown in Figure 4. Valves (10-B) and (5-B) of this reverse lock valve correspond with valves (10) and (5) of the I-Drive type. Valve (14-B) is a bypass valve which eliminates the need for a reverse interlock switch by allowing fluid return through the closed reverse lock valve when the fluid reaches a given pressure.

HYDRAULIC "DOWN" CIRCUIT (Figure 5)

When Power Trim pump is activated in the "down" direction, pressure is created in "down" side of hydraulic system (indicated by dark shaded area). This pressure moves slide valve (2) which unseats check ball (4) to allow fluid return. Fluid moves under pressure through valve body, connecting hoses, trim indicator sender (if unit is equipped with a hydraulic-type sender), reverse lock valve and on to the trim cylinders. At the cylinder, fluid flows between double walls (6) and into inner cylinder on "down" side of piston, where it moves the piston inward. Fluid on "up" side of system (3) is forced back through hoses to check valve (4) and into gears to supply fluid to the "down" side. Excess fluid, returning from "up" side, passes through valve (16) or (7) to return to reservoir.

Units, equipped with hydraulic-type trim indicator (as opposed to rotary electric-type), have a valve (12) which allows fluid to pass through the sender piston when it reaches the end of its travel, thus preventing excessive buildup of pressure.

Also, later style I-Drive reverse lock valves have a valve (17) which eliminates the need for the reverse interlock switch by providing a high-pressure bypass for returning fluid in the "up" side. This valve is similar in function to the valve (5-B) in the II-TR type reverse lock valve, shown in Figure 4.

SPECIAL FUNCTIONS (Figures 4 and 5)

Because of propeller thrust in reverse gear, valve (5) in reverse lock valve closes return passage of fluid and prevents upward travel of drive unit. In addition, the reverse interlock switch, installed on the reverse lock valve of some models, prevents pump running in "up" direction while in reverse gear, which would create excessive pressure.

Units, not equipped with this reverse interlock switch, have a later type reverse lock valve (Figure 5 inset) which has a bypass valve (17) for passage of returning fluid. Thus, this type of system may be trimmed "up" while in reverse gear, although, due to high pressure required to open bypass valve, trim action will not be the same as in forward or neutral gear.

Trail-out valve (7) holds drive unit in position during deceleration. Should unit strike a submerged object with light, steady pressure while in forward gear, trail-out valve will unseat and permit unit to clear the object. Valve (11) closes off its return passage to permit sufficient pressure to build up in order for trail-out valve to operate.

If a submerged object is hit with great force, rapid return of fluid through reverse lock valve seats the valve (10). This allows pressure to build up in cylinders sufficiently to open valve (8), which allows fluid to pass through piston and permits drive unit to clear submerged object. Valve (9) allows fluid to return through piston as unit comes back down to its original position.

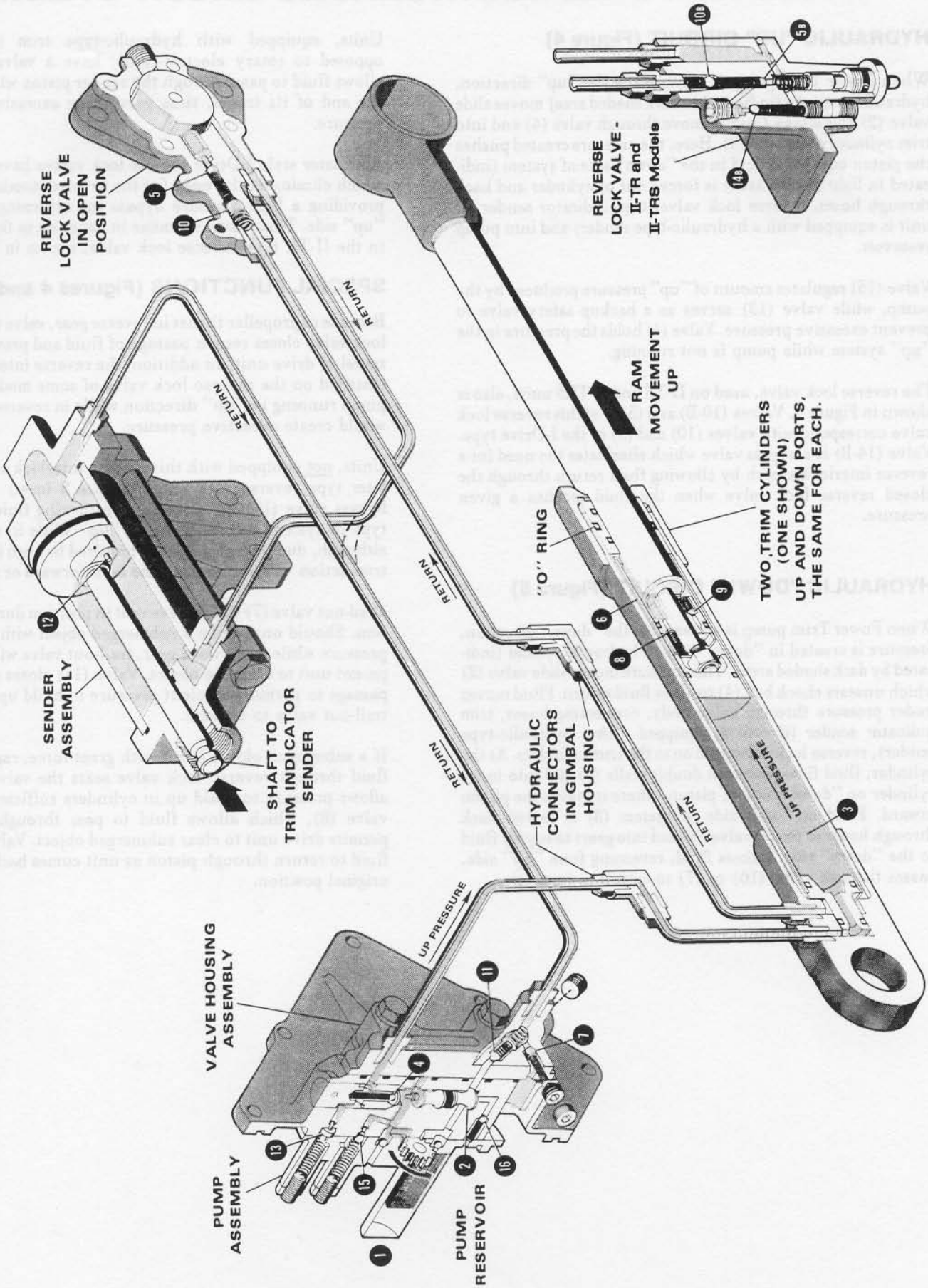


Figure 4. Hydraulic "Up" Circuit

POWER TRIM -HYDRAULIC "DOWN" CIRCUIT

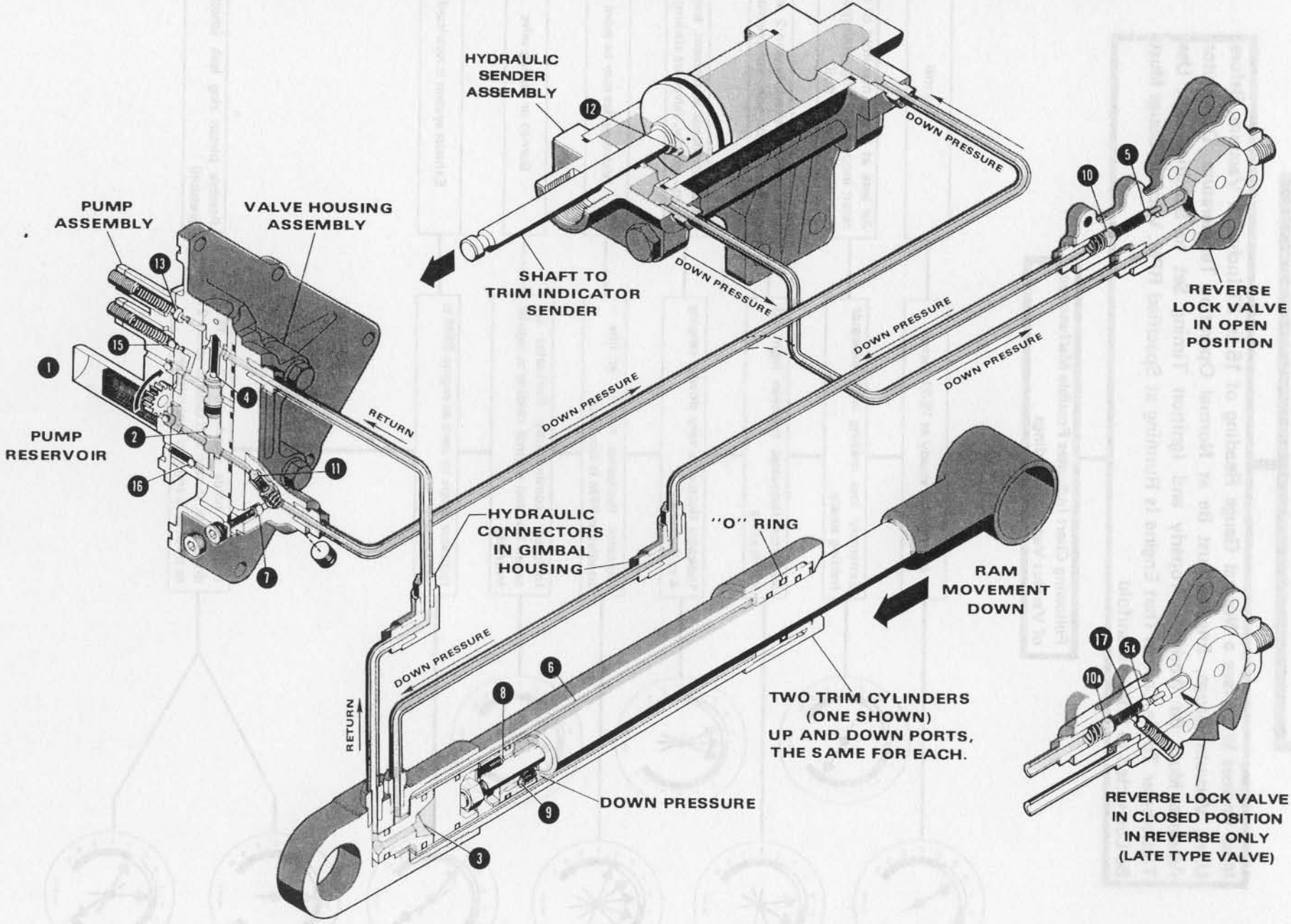
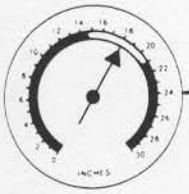


Figure 5. Hydraulic "Down" Circuit

Troubleshooting with a Vacuum Gauge

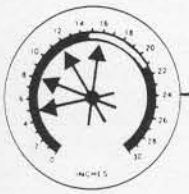
Most Engines Will Have a Normal Gauge Reading of 15 to 21 Inches of Vacuum. Before Using Vacuum Gauge, Engine Must Be at Normal Operating Temperature. Distributor Advance Must Be Working Properly and Ignition Timing Set to Specifications. Use Tachometer To Be Certain That Engine Is Running at Specified RPM. Vacuum Gauge Must Be Connected to Intake Manifold

Following Chart Indicates Possible Malfunctions of Various Vacuum Readings



Average and steady at 15-21 inches	Normal

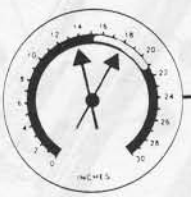
Extremely low reading with indicator holding steady	Air leak at intake manifold or carburetor; incorrect timing; underpowered boat; fault in boat hull



Indicator fluctuates between high and low reading	Blown head gasket between 2 adjacent cylinders (check with compression test)

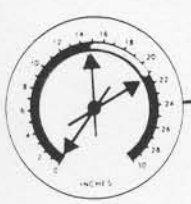
Indicator fluctuates very slowly, ranging 4 to 5 points	Carburetor needs adjustment, spark plug gap too narrow, valves are sticking

Indicator fluctuates rapidly at idle -- steadies as RPM is increased	Valve guides may be worn



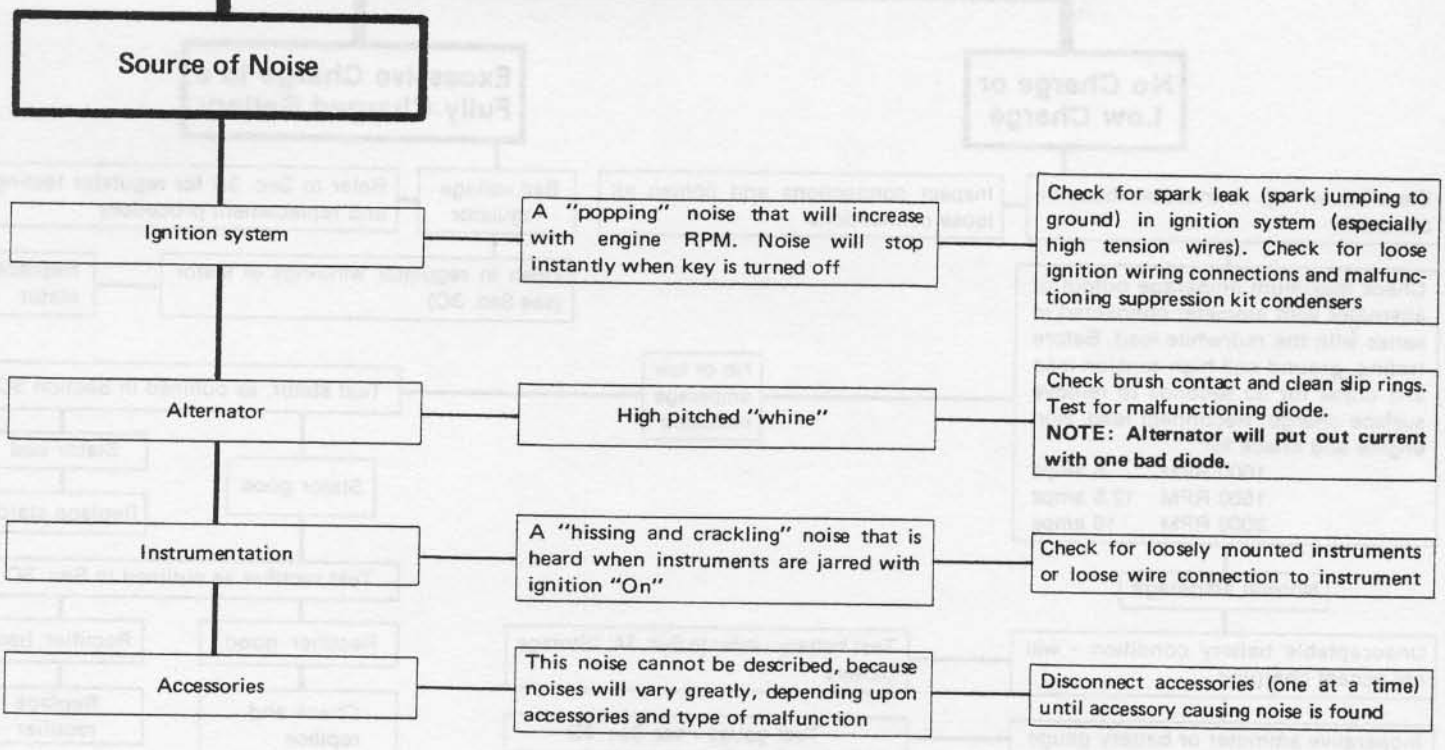
Indicator continuously fluctuates between low and normal reading at regular intervals	Burned or leaking valve

Indicator drops to zero as engine RPM is increased	Exhaust system is restricted

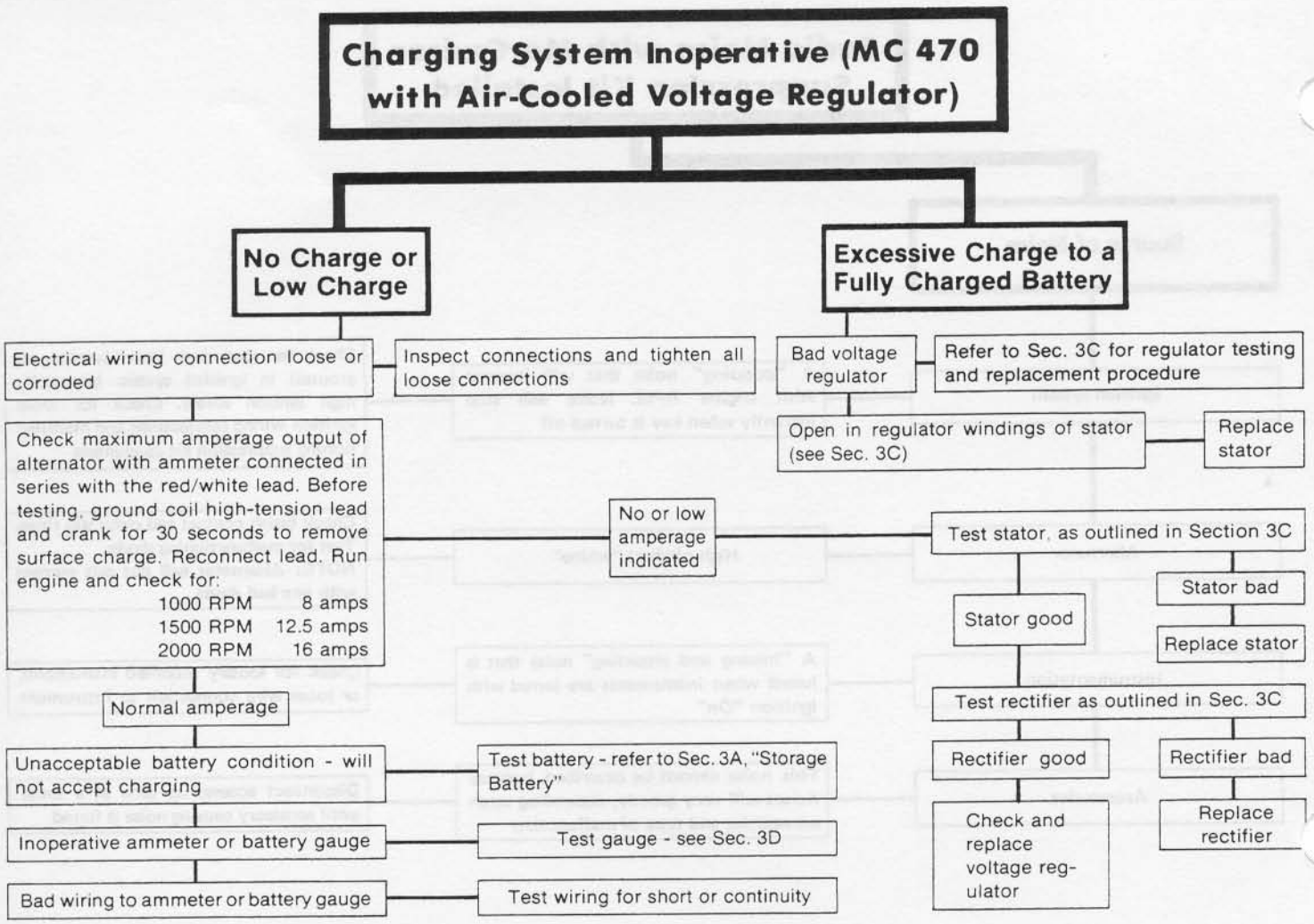


Indicator holds steady at 12 to 16 -- drops back to zero and back to about 21 as throttle is engaged and released	Possible piston ring leak (check compression)

Radio Noise with MerCruiser Suppression Kit Installed



Charging System Inoperative (MC 470 with Air-Cooled Voltage Regulator)



Charging System Inoperative (MC 470 with Water-Cooled Voltage Regulator)

NOTE: Battery must be fully charged and in good condition to perform these tests. If boat battery is questionable, a fully charged battery (known to be good) may be substituted for testing.

Check all connections to regulator. All terminals should be clean and all leads should be tight

MAXIMUM CHARGING TEST: Carefully disconnect regulator red (sensing) lead, and tape it safely away from contacting anything. Start engine and run at 1000 RPM just long enough to measure the charging current

- Good - about 25 amps
  - VOLTAGE REGULATION TEST: Reconnect red sense lead and connect DC Voltmeter directly across battery terminals. Run engine at 1000 RPM and observe reading
    - NOTE: If battery has been run down by testing, recharge it before this test to avoid running engine for an extended length of time
      - Current tapers back to about 12 amps or less
        - Measure battery voltage while engine is running and current has tapered back
          - 14.3±.5 volts
            - System good
          - Not 14.3±.5 volts
            - Closely recheck all wiring, including battery terminals. If no problem is found, replace voltage regulator and recheck from VOLTAGE REGULATION TEST
      - Battery voltage exceeds 14.3 ± .5 volts DC
        - Closely recheck all wiring, including battery terminals. If no problem is found, replace voltage regulator and recheck from VOLTAGE REGULATION TEST
- Any other value
  - STATOR TEST: Disconnect both stator wires and test for open or grounded stator (See Sec. 3-C)
    - Stator NOT open or grounded
      - Reconnect both yellow/red stator wires and run engine at 1000 RPM. Check for greatly different AC voltage readings from each yellow/red lead to ground
        - Great difference in AC voltages
          - Bad regulator - replace and recheck
        - AC voltage readings about the same
          - Bad (or weak) stator - replace and recheck
    - Stator open or grounded
      - Bad (or weak) stator - replace and recheck

Battery Condition Questionable

NOTE: Testing is required to determine the ability of a battery to function properly. The accuracy of the testing changes with temperature, specific gravity, age of the battery, etc. An accurate test has more than one step.

Step 1: Visual inspection

Step 2: Specific gravity check (hydrometer)

*Step 3: 421 test **

*Step 4: Load test **

Testing Cautions: Wear safety glasses. DO NOT break live circuits at battery terminals. When testing, be certain to remove gases at battery cover caused by charging.

**"421" and Load Test equipment is available from many automotive test equipment suppliers.*

STEP 1

Visual Inspection

Check for obvious damage, such as a cracked or broken case that shows loss of electrolyte

- Obvious damage
  - Replace battery
- No obvious damage
  - Check electrolyte level
    - Below top of plates in one or more cells
      - Add water to just above separators but not to split ring
      - Charge for 15 minutes @ 15-25 amps with non-flame arrestor vent caps removed but leave flame arrestor caps in place
    - Electrolyte level above top of plates in all cells — proceed to Step 2

STEP 2

Specific Gravity (Hydrometer) Test

- 50 points or more variation between highest and lowest cell
  - Replace battery
- Less than 50 points variation between highest and lowest cell
  - Specific gravity 1.100 @ 80° or more in all cells
    - If "421" tester is available, go to Step 3. If not available, go to Step 4. (6 and 8 volt, proceed to Step 4)
  - Specific gravity less than 1.100 in one or more cells
    - Proceed to Step 4

STEP 3

- Connect 300 amp load for 15 seconds
  - "421" test
    - Meter reading "bad"
      - Replace battery
    - Meter reading "good"
      - No history of trouble
        - Fully charge, clean, add water to split ring and return battery to service
      - History of trouble; proceed to Step 4

STEP 4

- Load test
  - Charge battery, if necessary, until all cells are at least 1.200 specific gravity. Remove all vent caps
    - If unable to obtain specific gravity of 1.200 @ 80° in all cells
      - Replace battery
    - Specific gravity of 1.200 or more @ 80° in all cells
      - Connect 300 amp load for 15 seconds
        - "Smoke" in one or more cells
          - Replace battery
        - "No smoke"
          1. Place thermometer in one cell
          2. Apply load equal to 3 times the ampere-hour rating of the battery (2 times for 6-volt batteries)
          3. Read voltage at 15 seconds with load connected
          4. Remove load and read electrolyte temperature, then compare voltage and temperature readings with chart below
          - Less than voltage on chart
            - Replace battery
          - Same as or greater than voltage on chart
            - Fully charge, clean, add water to split ring and return battery to service

BATTERY VOLTAGE and TEMPERATURE CHART (Fahrenheit)

Voltage must not drop below minimum listed at given temperature when battery is subjected to the proper load for 15 seconds and is 1.200 specific gravity @ 80° or more.

MINIMUM VOLTAGES									
Voltage	Electrolyte Temperature Down To:								
	80°	70°	60°	50°	40°	30°	20°	10°	0°
6-Volt	4.8	4.8	4.7	4.7	4.6	4.5	4.4	4.3	4.2
8-Volt	6.4	6.4	6.3	6.2	6.1	6.0	5.9	5.7	5.6
12-Volt	9.6	9.6	9.5	9.4	9.3	9.1	8.9	8.7	8.5